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CONTENTS **PAGES**

BOCK, P. E. & COOK, P. L. 63–68
A new species of multiphased *Corbulipora* MacGillivray, 1895 (Bryozoa: Cribriomorpha) from southwestern Australia.

CORBETT, D. W. 107–136
Douglas Mawson: the geologist as explorer.

MURRAY, P. F. 43–61
Thylacinus megiriani, a new species of thylacine (Marsupialia: Thylacinidae) from the Ongeva Local Fauna of Central Australia.

OKUNO, J. 13–18
A new shrimp of the genus *Rhynchocinetes* from the Great Australian Bight (Crustacea: Decapoda: Rhynchocinetidae).

PICHELIN, S. 19–27
Pomphorhynchus heronensis sp. nov. (Acanthocephala: Pomphorhynchidae) from *Lutjanus carponotatus* (Lutjanidae) from Heron Island, Australia.

QUEALE, L. F. 29–33
Field identification of female little brown bats *Vespadelus* spp. (Chiroptera: Vespertilionidae) in South Australia.

SOUTHCOTT, R. V. 1–12
Description of two new larval Smarididae (Acarina) from Australia.

WATTS, C. H. S. 35–42
Four new species of *Antiporus* Sharp (Coleoptera, Dytiscidae) from Australia, with notes on *A. femoralis* (Boh.) and *A. interrogationis* (Clark).

WATTS, C. H. S. 93–106
Revision of Australian *Amphiops* Erichson, *Allocotocerus* Kraatz and *Regimbartia* Zaitzev (Coleoptera: Hydrophilidae).

WATTS, C. H. S. 137–156
Revision of Australian *Enochrus* Thomson (Coleoptera: Hydrophilidae).

WILLIAMS, E. 69–91
The archaeology of lake systems in the middle Cooper Basin, north-eastern South Australia.

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DESCRIPTION OF TWO NEW LARVAL SMARIDIDAE (ACARINA) FROM AUSTRALIA

R. V. SOUTHCOTT

SOUTHCOTT, R. V. 1997. Description of two new larval Smaridídae (Acarina) from Australia. *Records of the South Australian Museum* **30**(1): 1–12.

Two new Australian larvae of Smaridídae (Acarina) are described, *Smaris arenicola* sp. nov. and *Sphaerotarsus monticolus* sp. nov., both from South Australia, from soil and litter. Each is the second species known as larva in its genus; both earlier described species were also Australian. The term AME is introduced in the coding of the metric data of the larval dorsal scutum.

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The mite family Smaridídae Vitzthum, 1929 is cosmopolitan, most members being known as adults. The adults (and deutonymphs) are small mites, of a generally flattened stature, living as predators in litter or under the bark of trees. These mites are mostly known from their adult instars. The larvae are probably all ectoparasitic on small arthropods, as is the case with most other members of the superfamily Erythraeoidea. Thus one Australian larva, *Smaris prominens* (Banks, 1916) , has been found as an ectoparasite of small Psocoptera (Womersley & Southcott 1941). A taxonomic and historical review of the family was given by Southcott (1961a). Seven genera are known as larvae (Southcott 1995). Of these two are Australian, each with a single described species; that of *Smaris prominens* (Banks, 1916) (by Womersley & Southcott 1941), and of *Sphaerotarsus leptopilus* Womersley & Southcott, 1941 (by Southcott 1960). The present paper describes a further new species in each of these genera, both from South Australia, and known only as larvae.

Materials And Methods

Specimens described in this paper were obtained by Berlese funnel extractions of samples of soil and litter in South Australia. They were collected as active larvae, and each was confined individually in a small tube and various small arthropods were introduced as potential hosts, in an effort to elucidate life histories.

The larvae were eventually mounted in Hoyer's medium after first being cleared in 50% lactic acid solution. Microscopy was done with the use of Leitz Ortholux/Laborlux microscope equipped with phase contrast and polarizing facilities. Drawings were made with the use of a drawing apparatus.

Chaetotaxic and other nomenclature and coding are as in Southcott (1961b, c, 1963, 1992, 1995). The code AME is introduced as a measure of the anterior central emargination of the dorsal scutum. (In my previous papers I had misinterpreted the use of this term as ASBM, which was introduced by Fain & Elsen 1987). AME may be formally defined as the distance between the anterior end of the scutum, in the midline, to the central anterior point of the scutum; hence AME=ASBa – ASBM (Fain & Elsen).

The terms protorostral, deutorostral and tritorostral will be used for the anterior setae of the gnathosoma, following Newell (1957).

All measurements are in micrometres (μm) unless otherwise stated.

All specimens will be deposited in the South Australian Museum (SAM).

Systematics

Family SMARIDIDAE Vitzthum

Smaridídae Vitzthum, 1929: 69, 70; Womersley & Southcott 1941: 61; Southcott 1946: 173; 1948: 252; 1960: 149; 1961a: 174; 1961b: 413; 1961c: 133; 1963: 159; 1995: 57; Shiba 1976: 189.

Erythraeidae Womersley, 1934: 218 (part).

Smarisidae Grandjean, 1947: 1.

For other synonymy see Southcott 1961b: 413–414.

Genus *Smaris* Latreille

Smaris Latreille, 1796: 180; Womersley & Southcott 1941: 63; Southcott 1946:175; 1948: 252; 1960: 155; 1961a: 176–177; 1961b: 438: 1961c: 133; 1963: 163; 1995: 63.

Sclerosmaris Grandjean, 1947: 3, 53.

For other synonymy see Southcott1961b: 438–439.

Key To Larval *Smaris*

— PDS 27–29 µm long. AL scutalae blunt-ended. Sternala I thickened, well setulose .... *S. prominens* (Banks, 1916)

— PDS 28–45 µm long. AL scutalae pointed. Sternala I narrow, lightly setulose .... *S. arenicola* sp. nov.

Smaris arenicola sp. nov.
(Figs 1A–D, 2A,B)

Material examined

Holotype. South Australia: Loveday, 7–8.ix.1985, R. V. Southcott, larva ACA2158 from soil and litter sample TX244, site Map: Department of Lands, South Australia , Barmera-Loveday, 2nd Edition 1:10,000 6929–26, MR 466055 (140°25'03"E, 34°17'25"S), extracted by Berlese funnel live 6.x.1985; to Hoyer's medium 28.i.1991. SAM.

Paratypes. Same data as holotype, 21 larvae from same site and sample, ACA2150, 2152–2156, 2159–2173, extracted live similarly 24.ix.1985–10.x.1985; Hoyer's medium. SAM.

Diagnosis of larva

Anterior scutalae pointed. GeIII 65–72 µm long. PDS 28–45 µm long.

Description of larva (from slide-mounted holotype, supplemented by paratypes)

Colour in life red. Idiosoma 245 long, 180 wide; total length of animal 330.

Dorsal scutum transverse, oval, with slight central anterior emargination, minutely porose. Scutalae slender, pigmented, AL pointed, PL blunt-ended, with adnate to slightly outstanding setules. AL scutalae placed anterolaterally on scutum; PL placed posterolaterally; all near edge of scutum. Anterior sensillary setae placed about midway between levels of AL and PL scutalae bases; sockets of posterior sensillary setae lightly protruding, placed at about middle of posterior border of scutum. Anterior sensillary setae thin, but thicker than the filamentous posterior sensillary setae; all with slight setules in distal two-thirds, longer distally.

Metric data as in Table I.

Dorsal idiosomal setae about 41 in number, pigmented, blunt-ended, with short, barbed setules; anterior setae in indistinct rows across dorsum; posterior setae form a denser group.

Ventral surface of idiosoma: two sternalae between coxae I, pigmented, pointed, lightly setulose; sternalae II vestigial, presenting as small domes *c.* 5 across, between coxae II; between coxae III two intercoxalae 28 long, similar to sternalae I. Behind coxae III *c.* 11 setae similar to dorsals, 27–36 long, arranged approximately 2, 4, 4, 1, with a denser grouping towards posterior pole.

Legs fairly short and thick, similar to those of *Smaris prominens* (see Womersley & Southcott 1941); lengths (including coxae and claws): I 380, II 370, III 410. Coxalae and other leg scobalae pigmented, setulose, pointed. Supracoxala to leg I a slender, blunted peg, 5 long.

Leg specialized setae: SoGeI.77pd(23), VsGeI.90pd(4), SoTiI.50d(38), SoTiI.70pd(33), CpTi.75d(8)+SoTiI.76d(28), SoTiI.78d(12), VsTiI.83pd(6). SoGeII.51pd(15), SoTiII.03d(16), SoTiII.78d(10). SoGeIII.52d(14), SoTiIII.03d(12).

Tarsus I with SoTaI.37d(45), curved, strong, pointed; FaTaI..40ad(6); tarsus I also with an accompanying trichobothriala to the solenoidala, with several long setules, at .44d, seta 40 long. Tarsus II with SoTaII.35d(18), slender, nearly recumbent. FaTaII appears as a minute vestigial structure immediately alongside, i.e. posterior to, SoTaII. All tarsi with a long, slender, blade-like empodium, 23–27 long, over-reaching lateral claws, which are paired on each tarsus, about 18 long, each a pad with a number of long ventral onychotrichs.

Gnathosoma robust, pyriform, 77 long by 75 wide (combined). Cheliceral digits S-shaped, 16 long, sharp-pointed. Protorostral (galeal) seta simple, slender, pointed, 14 long. Deutorostral seta simple, conical, 7 long. Tritorostral setae simple, slender, pointed, 21 long. Palpal setal formula 0, 0, 1, 1, 3, 7 (including solenoiodala and terminala (eupathidala)); all setae (except palptarsal solenoidala) pointed; femorala, genuala and tibialae 1 and 2 setulose. Odontus pointed, hook-like, with two dorsal supplementary spurs behind tip. Palpal supracoxala dorsal in position, a clavate rod 5 long.

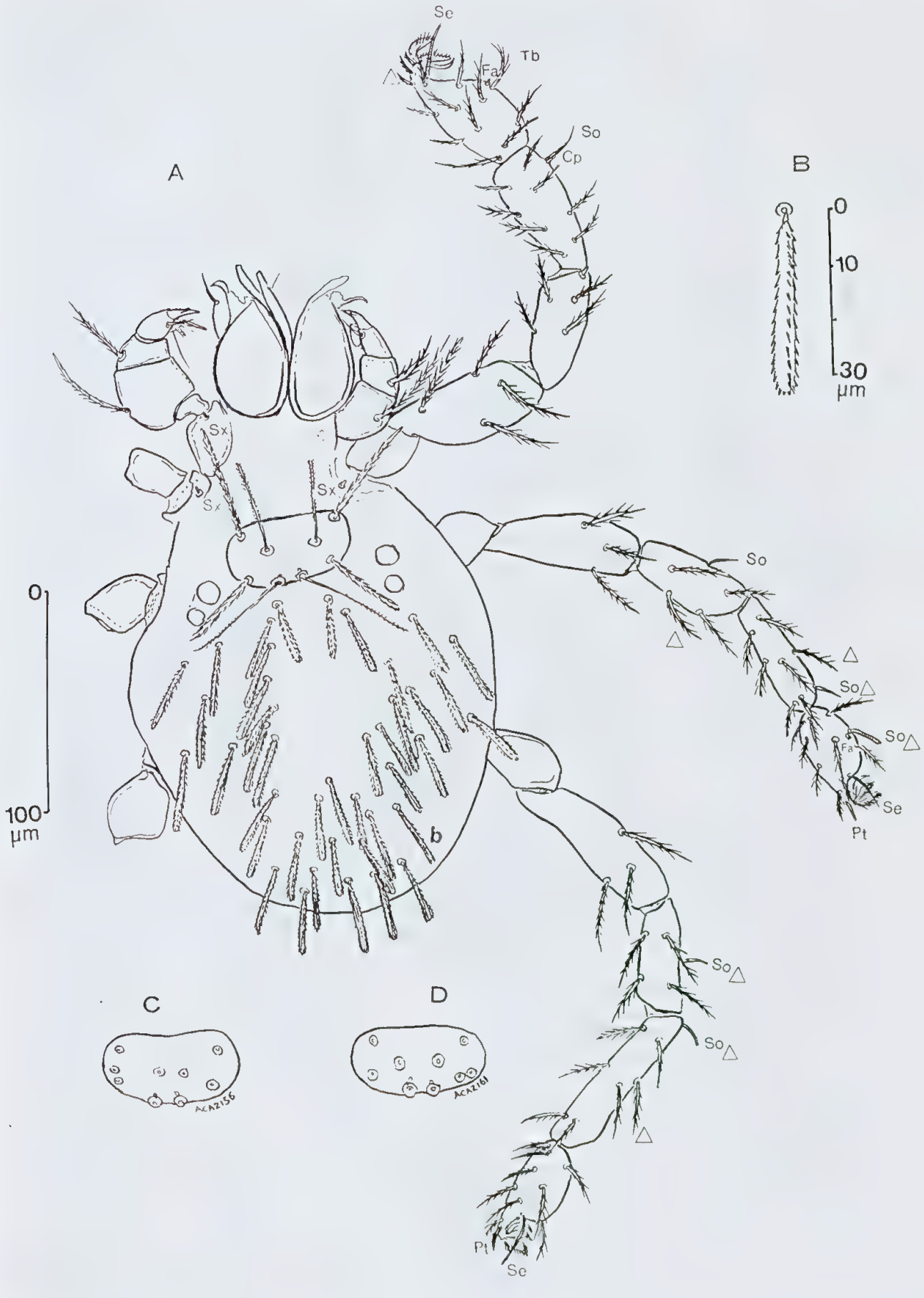

FIGURE 1. *Smaris arenicola* sp. nov., larva. A, B holotype; **A**, Dorsal view, on left legs omitted beyond trochanters; **B**, Dorsal idiosomal seta ('b' in A). C, D Paratypes: **C**, Teratological dorsal scutum of ACA2156; **D**, teratological dorsal scutum of ACA2161. (Each to nearest scale.)

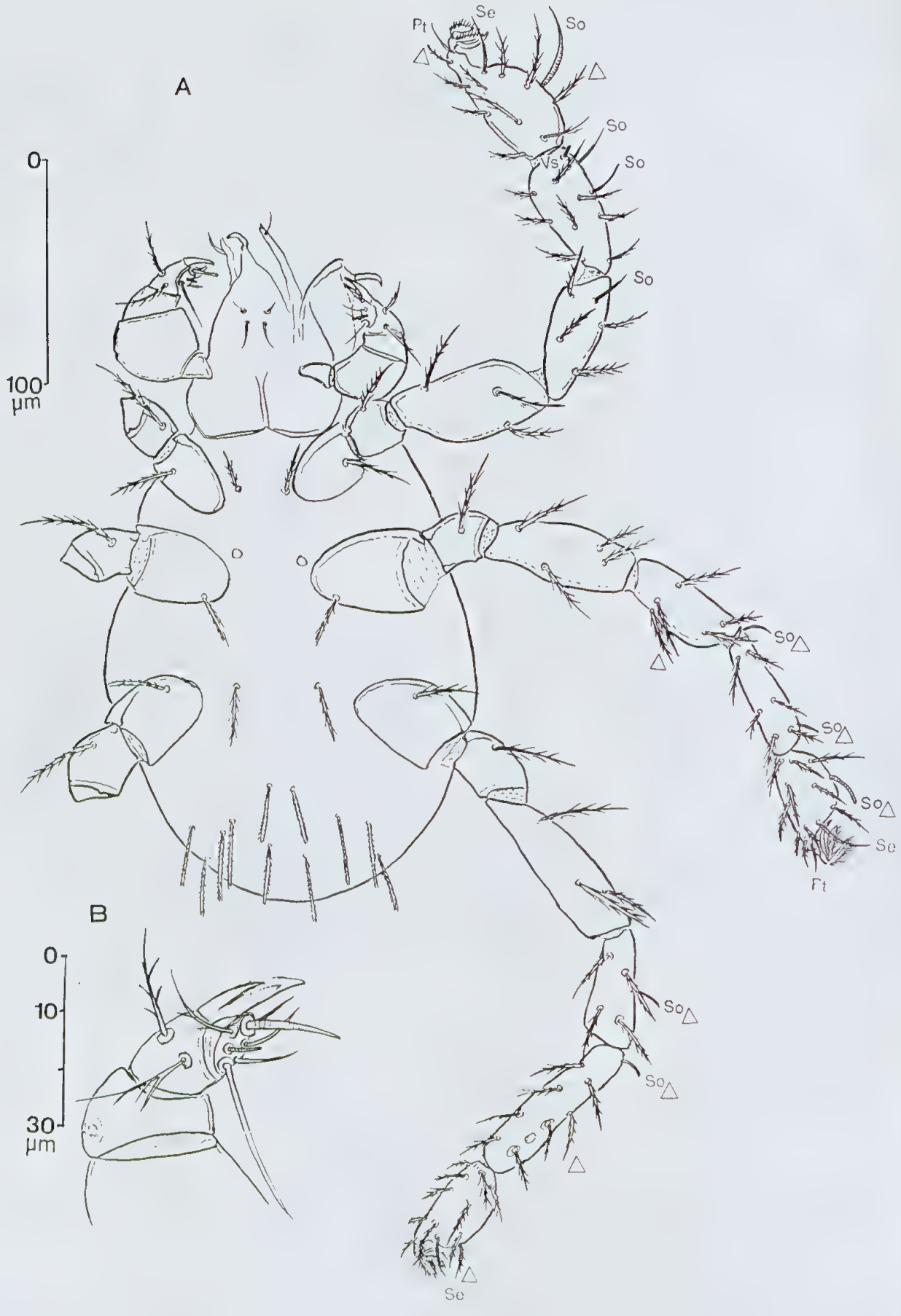

FIGURE 2. *Smaris arenicola* sp. nov., larva, holotype. **A**, Ventral view, on left legs omitted beyond trochanters. **B**, Tip of palp, ventral view, further enlarged.

TABLE 1. Metric data for *Smaris arenicola* sp. nov. larvae (*for maximum values)

Character	Holotype	n	range	mean	s.d.	c.v.
AW	47	22	43–49	45.5	1.37	3.0
PW	50	22	42–53	48.3	2.35	4.9
SBa	22	21	19–23	22.1	1.01	4.6
SBp	16	21	13–16	15.0	0.921	6.1
LX	8	21	6–12	8.81	1.21	13.7
ASBa	20	21	15–22	17.8	1.83	10.3
AME	2	21	1–3	2.10	0.436	20.8
ISD	15	21	14–17	15.0	0.805	5.4
L	38	21	34–39	35.8	1.34	3.7
W	63	21	58–72	63.7	3.44	5.4
AAS	16	21	14–16	15.1	0.831	5.5
A–P	20	21	15–20	16.9	1.64	9.7
AL	56	21	45–64	55.1	3.54	6.4
PL	43	22	36–47	42.1	2.83	6.7
ASE	40	21	36–44	39.7	1.93	4.9
PSE	65	19	60–73	66.2	3.92	5.9
DS	31–38	22	38–45*	41.0*	1.79*	4.4*
'Oc.'	37	22	36–42	38.1	1.98	5.2
MDS	32	22	32–38	34.4	1.99	5.8
PDS	31–38	22	38–45*	40.8*	2.05*	5.0*
GeI	68	22	60–69	64.7	1.93	3.0
TiI	66	22	60–69	64.7	2.12	3.3
TaI(L)	68	22	64–73	68.5	2.39	3.5
TaI(H)	33	22	27–35	32.2	2.56	7.9
TiI/GeI	0.97	22	0.92–1.07	1.00	0.0340	3.4
GeII	62	22	55–64	59.3	2.44	4.1
TiII	66	22	62–68	65.6	1.89	2.9
TaII(L)	50	22	47–60	52.8	3.15	6.0
TaII(H)	27	22	20–31	26.4	3.06	11.6
TiII/GeII	1.06	22	1.02–1.19	1.11	0.0490	4.4
GeIII	68	22	65–72	67.9	1.77	2.6
TiIII	93	22	86–93	89.9	2.04	2.3
TaIII(L)	55	22	49–61	56.3	2.64	4.7
TaIII(H)	26	22	20–29	25.0	2.29	9.2
TiIII/GeIII	1.37	22	1.28–1.38	1.32	0.0360	2.7
AW/ISD	3.13	21	2.75–3.36	3.04	0.187	6.1
ISD/A–P	0.75	21	0.75–1.07	0.887	0.0913	10.3
AW/A–P	2.35	21	2.15–3.00	2.71	0.260	9.6
StI	18	22	18–29	22.4	2.97	13.3
CxI	42	22	40–53	44.0	2.59	5.9
CxII	22	21	20–31	23.3	2.51	10.8
CxIII	31	21	26–36	32.1	2.78	8.6
TiI/AW	1.40	22	1.32–1.56	1.42	0.0668	4.7
TiIII/AW	1.98	22	1.83–2.12	1.98	0.0666	3.4
AW/AL	0.84	21	0.70–1.02	0.829	0.0599	7.2
AL/AAS	3.50	20	2.81–4.27	3.65	0.341	9.3
TiIII/TiI	1.41	22	1.28–1.44	1.39	0.0402	2.9
TiII/PW	1.32	22	1.22–1.57	1.36	0.0768	5.6
L/W	0.60	21	0.47–0.64	0.56	0.0416	7.4
PW/AW	1.06	22	0.93–1.18	1.06	0.0545	5.1
AL/PL	1.30	21	1.13–1.52	1.31	0.112	8.5

Etymology

The specific epithet *arenicola* means 'sand-dwelling' (Latin), a reference to the site of capture.

Biology

All larvae were captured free. In an attempt to find possible hosts larvae were introduced individually into small tubes, and various small arthropods introduced as potential hosts. These included various insects: small moths, small hemipterans (aphids, psyllids, a ?mirid), small Diptera and wingless Psocoptera; also a small spiderling. However, no attempt at parasitization by any of the mites was observed.

Genus *Sphaerotarsus* Womersley

Sphaerotarsus Womersley, 1936: 119; Womersley & Southcott 1941: 63, 73; Southcott 1960: 149; 1961a: 177; 1961b: 144; 1963: 211; 1995: 57, 63.

Definition of larva

One eye on each side. Anterior sensillary bases anterior to AL scutalae bases; posterior sensillary bases posterior to PL scutalae bases. Palpal tibial claw (odontus) apically simple or with narrow terminal split, and an outstanding basal accessory tooth. Genu I with 3–6 solenoidalae. Tibia I with four solenoidalae.

KEY TO LARVAL *SPHAEROTARSUS*

— PDS to 127 µm long .... *S. leptopilus* Womersley & Southcott, 1941

— PDS to 86 µm long ..... *S. monticolus* sp. nov.

Sphaerotarsus monticolus sp. nov.
(Figs. 3A,B, 4A,B)

Material examined

Holotype. South Australia. Mt. Lofty, 5–20.x.1991, R. V. Southcott, larva ACA2556, in damp soil and litter in *Eucalyptus obliqua* forest, sample TX320, site at Map: Adelaide 6628–111, 1:50,000, MR 897282 (138°41'47" E., 34°58'03" S.), sample collected 5.x.1991, extracted live by Berlese funnel 20.x.1991. Cleared with 50% lactic acid, mounted in Hoyer's medium.

Paratypes. South Australia. Hope Forest, 11.ix.1980, RVS, in moss under *Eucalyptus baxteri* forest, at Map Reference Milang 1:63,360 617393 (138°36'19"E., 35°18'06"S.), site TX198, extracted by Berlese funnel 14–23.ix.1980. Stirling, at Map Reference Adelaide 1:50,000, 2nd Edtn., 934258 (138°44'0"E., 34°59'30"S.), 11.xi.1984, RVS, sample TX232 of soil, litter and grass under *Eucalyptus hueberiana*, extracted by Berlese funnel 17.xi.1984.

Diagnosis of larva

PDS to 66 µm long.

Description of larva (from slide-mounted holotype)

Colour in life: idiosoma orange, legs pale orange. Idiosoma 325 long, 220 wide. Total length to tip of cheliceral digits 410; in life these dimensions were 300, 200, 380 respectively.

Dorsal scutum trapezoidal, with rounded anterior end and acute posterior end; scutum minutely porose. Scutum has a sclerotized ridge enclosing the anterior and posterior sensillary areas, of a tear-drop shape, the point posteriorad, and within the bases of the four scutalae. Scutalae pointed, with many fine, pointed setules. Anterior sensillary setae thicker than the filamentous posterior sensillary setae; all sensillary setae with fine setules in distal half of setal shaft.

Metric data as in Table 2.

Eyes 1+1, lateral to scutum, 18 across.

Dorsum of idiosoma with 24 setae, pigmented, expanding slightly distally, blunt-ended, with many fine setules; setae arranged approximately 6, 4, 2, 4, 2, 4, 2.

Ventral surface of idiosoma: sternalae I pointed, setulose; sternalae II absent; anterior to coxae III a pair of intercoxalae similar to sternalae I, 36 long, 60 apart. Behind coxae III are 10 pointed, setulose setae, arranged 4, 2, 2, 2.

Legs somewhat longer than idiosoma; lengths (including coxae and claws): I 400, II 395, III 495. Leg scobalae pointed, lightly setulose. Supracoxala to leg I blunted, 4 long.

Leg specialized setae: TbGeI.44ad(25), TbGeI.44pd(22), SoGeI.60pd(23), SoGeI.67d(16), SoGeI.76pd(17), VsGeI.90d(3), TbTiI.48pd(28), TbTiI.53ad(29), TbTiI.54pv(27), TbTiI.54av(29), SoTiI.61pd(30), SoTiI.67d(30), SoTiI.77pd(30), CpTiI.80ad(9)+ScTiI.82ad(30), SoTiI.86d(25), VsTiI.95pd(2). VsGeII.88d(1), SoTiII.11d(14), SoTiII.86d(10). SoTiIII.09d(18).

Tarsus I with SoTaI.17ad(20), TbTaI.20pd(22), CpTaI.40ad(9)+SoTaI.42ad(22), FaTaI.58ad(1), CpTaI.70d(6)+TbTaI.71d(29). Tarsus II with SoTaII.39d(20). Lateral tarsal claws with a few slender onychotrichs; empodium slender, over-reaching lateral claws.

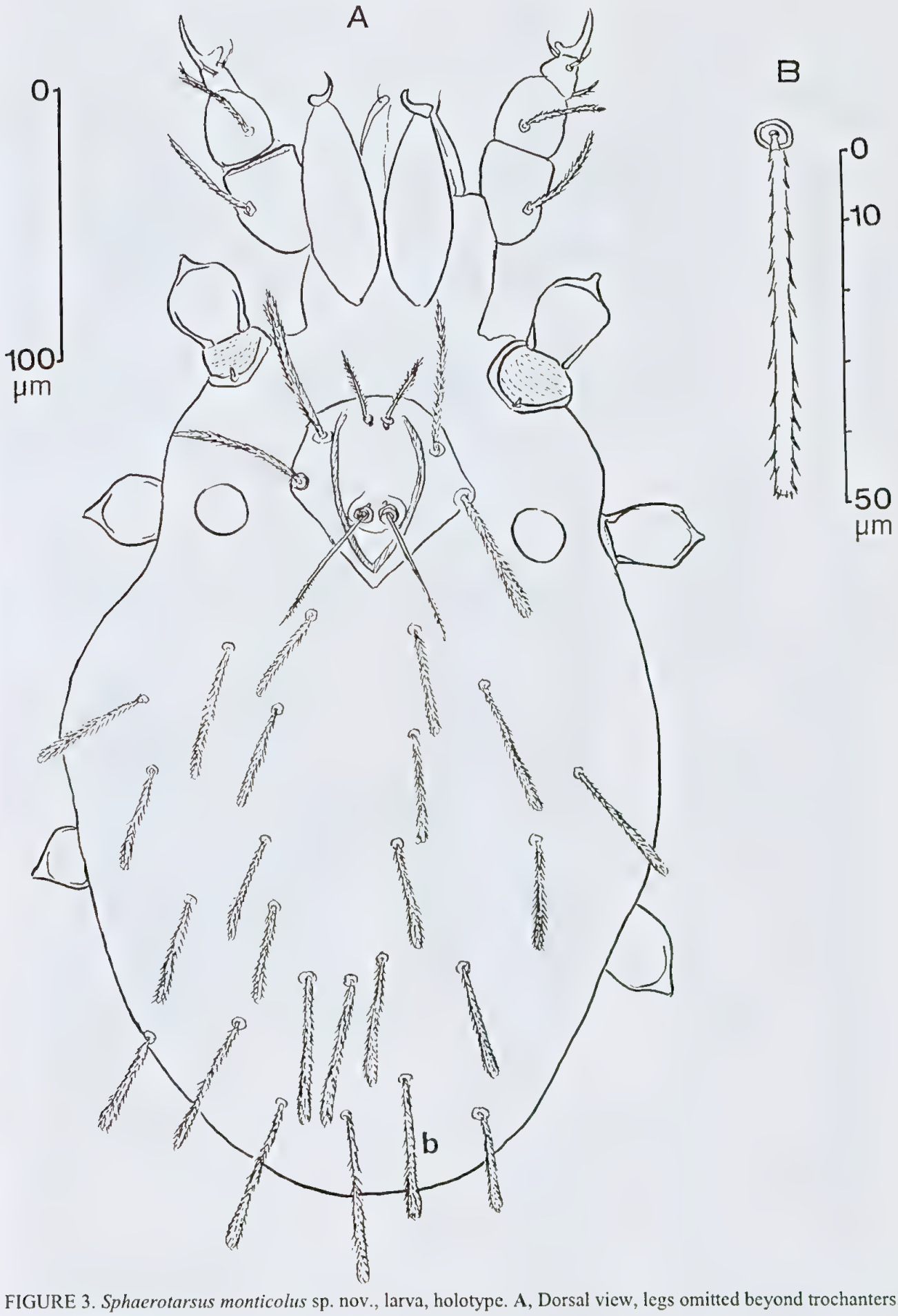

FIGURE 3. *Sphaerotarsus monticolus* sp. nov., larva, holotype. **A**, Dorsal view, legs omitted beyond trochanters. **B**, Dorsal idiosomal seta ('b' in A), further enlarged.

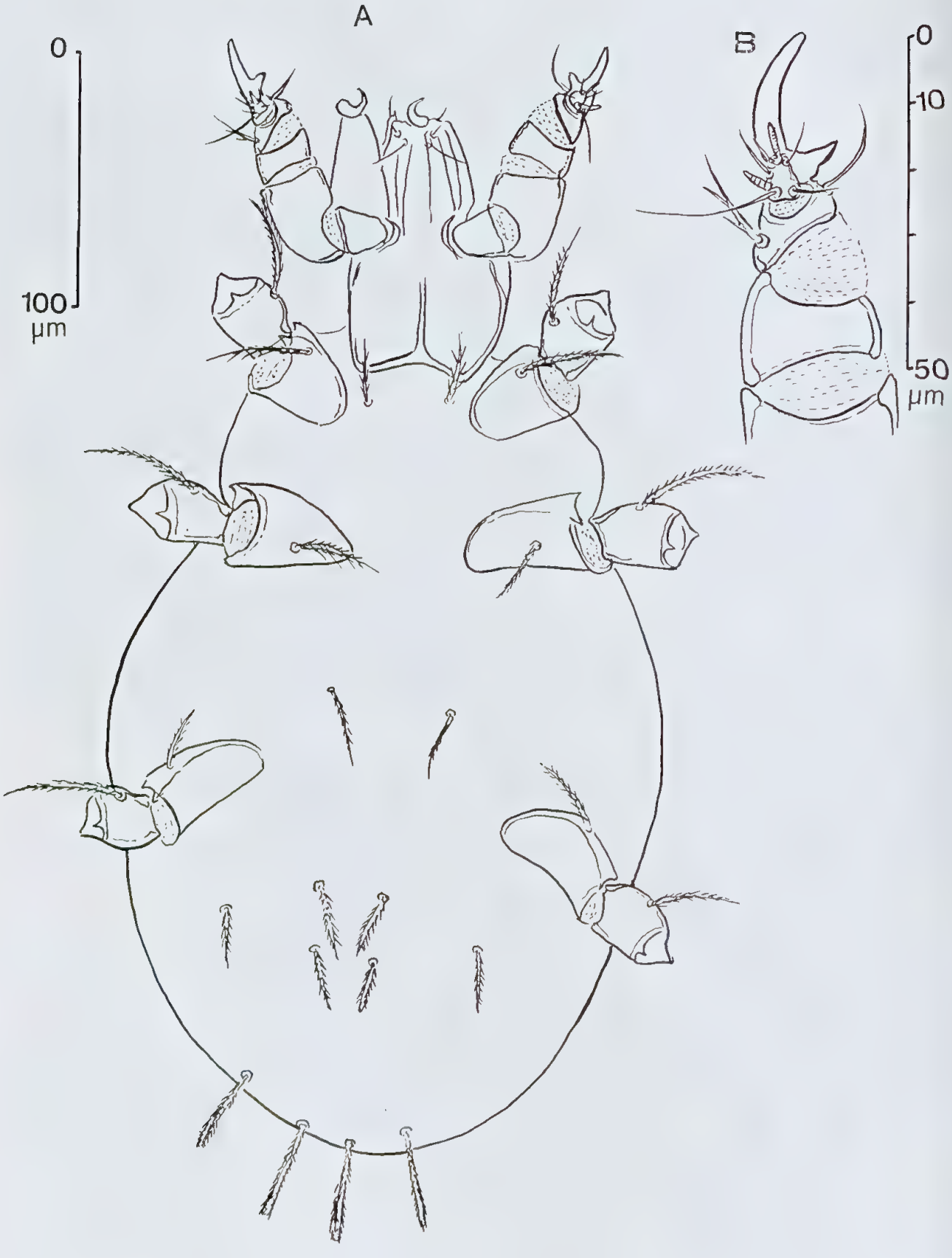

FIGURE 4. *Sphaerotarsus monticolus* sp. nov., larva, holotype. **A**, Ventral view, legs omitted beyond trochanters. **B**, Tip of palp, ventral view, further enlarged.

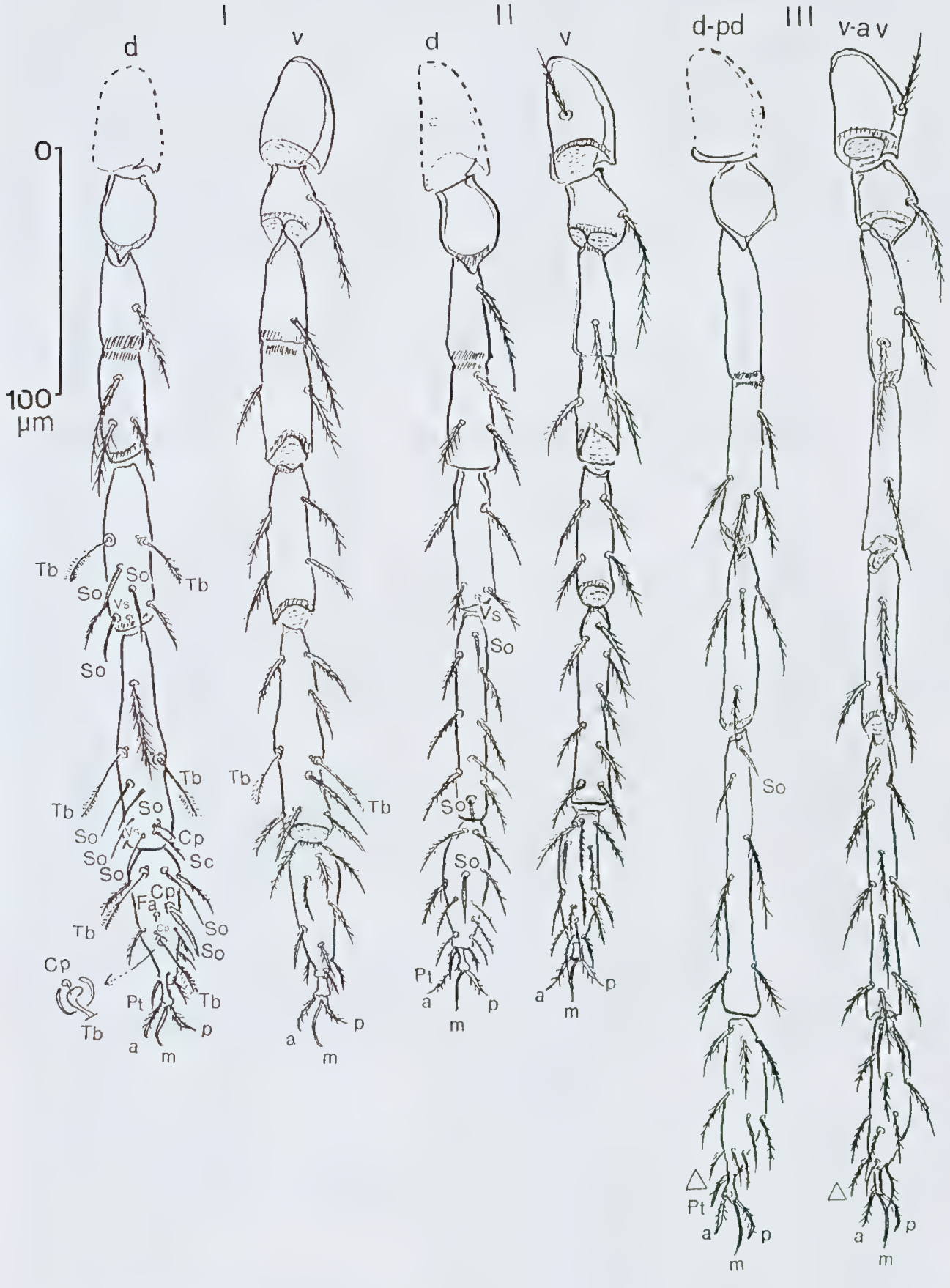

FIGURE 5. *Sphaerotarsus monticolus* sp. nov., larva, holotype. Legs I, II, III. (All to scale shown.)

TABLE 2. Metric data for *Sphaerotarsus monticolus* sp. nov. larvae (*for maximum values)

Character	Holotype	n	range	mean	s.d.	c.v.
AW	43	10	36–47	41.7	2.98	7.2
PW	55	10	47–66	56.8	6.44	11.3
SBa	8	10	6–13	10.6	2.17	20.5
SBp	12	10	11–14	12.2	1.40	11.5
LX	17	10	15–23	20.1	3.00	14.9
ASBa	10	10	9–16	13.4	2.76	20.6
AME	0	10	0–1	0.10	0.316	3.2
ISD	35	10	30–38	34.5	2.99	8.7
L	66	10	63–78	72.1	5.24	7.3
W	64	10	59–75	67.3	6.38	9.5
AAS	19	10	15–22	17.5	2.01	11.5
A–P	19	10	14–30	21.7	5.29	24.4
AL	58	10	57–78	66.6	7.88	11.8
PL	57	10	57–80	67.8	9.26	13.7
ASE	21	10	21–29	25.9	2.85	11.0
PSE	49	10	49–68	57.5	6.43	11.2
DS	42–66	10	55–86*	73.5*	10.5*	14.2*
'Oc.'	45	10	45–73	58.5	9.92	17.0
MDS	45	10	40–73	54.4	11.8	21.8
PDS	66	10	55–86*	73.5*	10.5*	14.2*
GeI	73	10	72–82	76.5	3.37	4.4
TiI	91	10	82–97	89.6	4.93	5.5
TaI(L)	55	10	52–67	60.4	5.19	8.6
TaI(H)	22	10	22–33	27.2	9.15	33.6
TiI/GeI	1.25	10	1.11–1.25	1.16	0.0372	3.2
GeII	60	10	56–85	62.0	4.00	6.5
TiII	85	10	76–86	82.3	4.27	5.2
TaII(L)	52	10	51–60	55.7	3.71	6.7
TaII(H)	18	10	18–26	22.4	2.41	10.8
TiII/GeII	1.02	10	1.02–1.40	1.28	0.107	8.3
GeIII	78	10	72–90	82.0	6.86	8.4
TiIII	124	10	114–140	127.0	8.56	6.7
TaIII(L)	63	10	62–75	66.8	4.54	6.8
TaIII(H)	17	10	17–24	21.5	2.22	10.3
TiIII/GeIII	1.59	10	1.48–1.74	1.56	0.0707	4.5
AW/ISD	1.23	10	1.05–1.67	1.24	0.184	14.9
ISD/A–P	1.84	10	1.20–2.29	1.66	0.340	20.5
AW/A–P	2.26	10	1.54–3.36	2.04	0.596	29.2
StI	34	10	29–35	32.9	1.79	5.4
CxI	49	10	49–62	55.6	4.03	7.3
CxII	37	10	34–48	38.0	4.22	11.1
CxIII	34	10	33–41	37.6	3.57	9.5
TiI/AW	2.12	10	1.81–2.28	2.16	0.184	8.5
TiIII/AW	2.88	10	2.66–3.50	3.08	0.242	7.9
AW/AL	0.74	10	0.51–0.82	0.635	0.0901	14.2
AL/AAS	3.05	10	2.59–4.59	3.85	0.608	15.8
TiIII/TiI	1.36	10	1.36–1.50	1.44	0.0505	3.5
TiII/PW	1.55	10	1.27–1.61	1.43	0.144	10.0
L/W	1.03	10	1.03–1.17	1.07	0.0572	5.3
PW/AW	1.26	10	1.01–1.61	1.40	0.198	14.2
AL/PL	1.02	10	0.88–1.09	0.988	0.0601	6.1

Gnathosoma comparatively slender; cheliceral bases 64 long by 50 wide (combined); cheliceral blades 16 long, slender, curved, pointed. Protorostral setae simple, pointed, 9 long. Deutorostral setae small, pointed, *c.* 5 long. Tritorostral setae slender, simple, pointed, *c.* 18 long. Palpi fairly robust, with setal pattern 0, 0, 1, 1, 3, 7 including solenoidala and eupathidala (terminala). Palpal femorala and genuala blunt-ended, setulose; palpal tibiala 1 pointed, setulose; palpal tibialae 2 and 3 simple, pointed. Odontus simple, with strong ventral, conical, blunted tooth. Supracoxala not identified.

Etymology

The specific epithet is an adjective, meaning 'mountain dwelling' (Latin).

Biology

Some observations were made on the living larva ACA2121. On capture it appeared active and healthy; it was identified in life by being weighted down on a slide by a small cover glass, and examined at 400 diameters magnification. After release it became quite active again. It was placed in a small dry tube, and droplets of water given .Various small arthropods recovered from the berlesate were offered as potential hosts over several days: a small coccid (Hemiptera), 7–8 Collembola (?Isotomidae) and an immature psocopteran. However, no attempt at parasitization was observed during the nine days it survived in the tube,

ACKNOWLEDGMENTS

The work was done with the support of a grant from the Australian Biological Resources Study.

REFERENCES

BANKS, N. 1916. Acarians from Australian and Tasmanian ants and ant-nests. *Transactions of the Royal Society of South Australia* **40**: 224–240.

FAIN, A., & ELSEN, P. 1987. Observations sur les larves du genre *Leptus* Latreille, 1795 (Acari, Erythraeidae) d'Afrique centrale. *Revue de Zoologie Africaine* **101**: 103–123.

GRANDJEAN, F. 1947. Étude sur les Smarisidae et quelques autres Érythraeoides (acariens). *Archives de Zoologie expérimentale et générale* **85** (1): 1–126.

LATREILLE, P. A. 1796 'Précis des Caractères génériques des insectes, disposés dans un ordre naturel.' Prévôt, Paris, & F. Bourdeaux, Brive, an 5 de la R.

NEWELL, I. M. 1957. Studies on the Johnstonianidae (Acari, Prostigmata). *Pacific Science* **11** (4): 396–466.

SHIBA, M. 1976. Taxonomic investigation on free-living Prostigmata from the Malay Peninsula. *Nature & Life in Southeast Asia* **7**: 83–229.

SOUTHCOTT, R. V. 1946. On the family Smarididae (Acarina). *Proceedings of the Linnean Society of New South Wales* **70** (3–4), 173–178.

SOUTHCOTT, R. V. 1948. Larval Smarididae (Acarina) from Australia and New Guinea. *Proceedings of the Linnean Society of New South Wales* **72** (5–6): 252–264.

SOUTHCOTT, R. V. 1960. Notes on the genus *Sphaerotarsus* (Acarina, Smarididae). *Transactions of the Royal Society of South Australia* **83**: 149–161.

SOUTHCOTT, R. V. 1961a. Notes on the genus *Caeculisoma* (Acarina: Erythraeidae), with comments on the biology of the Erythraeoidea. *Transactions of the Royal Society of South Australia* **84**: 163–178.

SOUTHCOTT, R. V. 1961b Studies on the systematics and biology of the Erythraeoidea, with a critical revision of the genera and subfamilies. *Australian Journal of Zoology* **9** (3): 367–610.

SOUTHCOTT, R. V. 1961c . Description of two new Australian Smarididae (Acarina), with remarks on chaetotaxy and geographical distribution. *Transactions of the Royal Society of South Australia* **85**: 133–153.

SOUTHCOTT, R. V. 1963. The Smarididae (Acarina) of North and Central America and some other countries. *Transactions of the Royal Society of South Australia* **86**: 159–245.

SOUTHCOTT, R. V. 1992. Revision of the larvae of *Leptus* Latreille (Acarina: Erythraeidae) of Europe and North America, with descriptions of post-larval instars. *Zoological Journal of the Linnean Society* **105** (1): 1–153.

SOUTHCOTT, R. V. 1995. A new larval smaridid mite (Acarina: Smarididae) from Costa Rica. *Acarologia* **36** (1): 57–64.

VITZTHUM, H. 1929. Ordnung Milben, Acari. Pp. 1–112 *in* 'Die Tierwelt Mitteleuropas', Volume **3**, Section 7. Quelle & Mayer: Leipzig.

WOMERSLEY, H. 1934. A revision of the trombid and erythraeid mites of Australia with descriptions of new genera and species. *Records of the South Australian Museum* **5** (2): 179–254.

WOMERSLEY, H. 1936 Additions to the trombidiid and erythraeid acarine fauna of Australia and New Zealand. *Linnean Society's Journal-Zoology* **40** (269): 107–121.

WOMERSLEY, H., & SOUTHCOTT, R. V. 1941. Notes on the Smarididae (Acarina) of Australia and New Zealand. *Transactions of the Royal Society of South Australia* **65** (1): 61–78.

A NEW SHRIMP OF THE GENUS *RHYNCHOCINETES* FROM THE GREAT AUSTRALIAN BIGHT (CRUSTACEA: DECAPODA: RHYNCHOCINETIDAE)

JUNJI OKUNO

OKUNO, J. 1997. A new shrimp of the genus *Rhynchocinetes* from the Great Australian Bight (Crustacea: Decapoda: Rhynchocinetidae). *Records of the South Australian Museum* 30(1): 13–18.

A new shrimp of the family Rhynchocinetidae, *Rhynchocinetes enigma*, is described and illustrated on the basis of two males and an ovigerous female from the Great Australian Bight. This species is readily distinguished from the other eleven congeners by the absence of an arthrobranch from the third maxilliped, or lack of an arthrobranch on the pereiopods. It represents the fourth rhynchocinetid species from depths exceeding 100 m.

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Caridean shrimps belonging to the family Rhynchocinetidae are distinguished from other carideans in the combination of having a typically movable rostrum, fine transverse striae on the surface of the carapace and abdominal somites, the first two pairs of pereiopods robust, with fingers bearing long lateral and terminal spines, and the second pereiopod with the carpus entire, not subdivided. To date, this family includes two genera, *Rhynchocinetes* H. Milne-Edwards and *Cinetorhynchus* Holthuis (Okuno 1996b, in press).

Through the courtesy of Ms K. Gowlett-Holmes of the South Australian Museum, Adelaide (SAM), I was able to examine two male and one ovigerous female specimens of an unfamiliar *Rhynchocinetes* species collected by trawling from the Great Australian Bight at depths between 113 and 170 m. These specimens do not possess arthrobranchs, although the previously described congeners at least have arthrobranchs on the third maxilliped and the first pereiopod. Because of these differences, they are described herein as new species.

The postorbital carapace is abbreviated as CL, and the type specimens are deposited in SAM.

Rhynchocinetes enigma sp. nov.
(Figs. 1–3)

Material Examined

Holotype. Male (SAM C5599, 6.8 mm CL), 34°17'S, 132°42'E, Great Australian Bight, approximately 15 km west-south-west of Pearson Islands, 140–160 m depth, 'F. V. Comet', April 16, 1989.

Paratypes. Ovigerous female (SAM C5598, 9.0 mm CL), 33°12'S, 130°53'E, Great Australian Bight, 250 km south-south-west of Ceduna, 113 m depth, 'F. R. V. Soela', August 5, 1981. Male (SAM C5600, 7.6 mm CL), 33°18'S, 127°38'E, Great Australian Bight, approximately 115 km south-west of Eucla, 170 m depth, 'F. V. Comet', January 17, 1989.

Diagnosis

A species of *Rhynchocinetes* without arthrobranchs on maxillipeds and pereiopods. Dorsal rostral margin armed with three subterminal teeth. Fourth abdominal somite with distinct posteroventral tooth on pleuron. Ambulatory pereiopods with meri bearing three spines, and dactyli with four accessory claws posterior to terminal claw. Endopod of male first pleopod with distinct lobe on outer margin.

Description

Carapace (Fig. 2A) covered with fine transverse striae, armed with two acute teeth on dorsal median carina, anterior tooth just behind rostral articulation, posterior tooth feebly articulated with carapace; supraorbital spine acute, considerably longer than spines on dorsal median carina, directed anteriorly; antennal spine acute, supported by a feeble carina, directed anteriorly; pterygostomial spine small, distinct. Rostrum (Fig. 2A) articulated with carapace, 1.10 – 1.28x as long as carapace; dorsal margin armed with

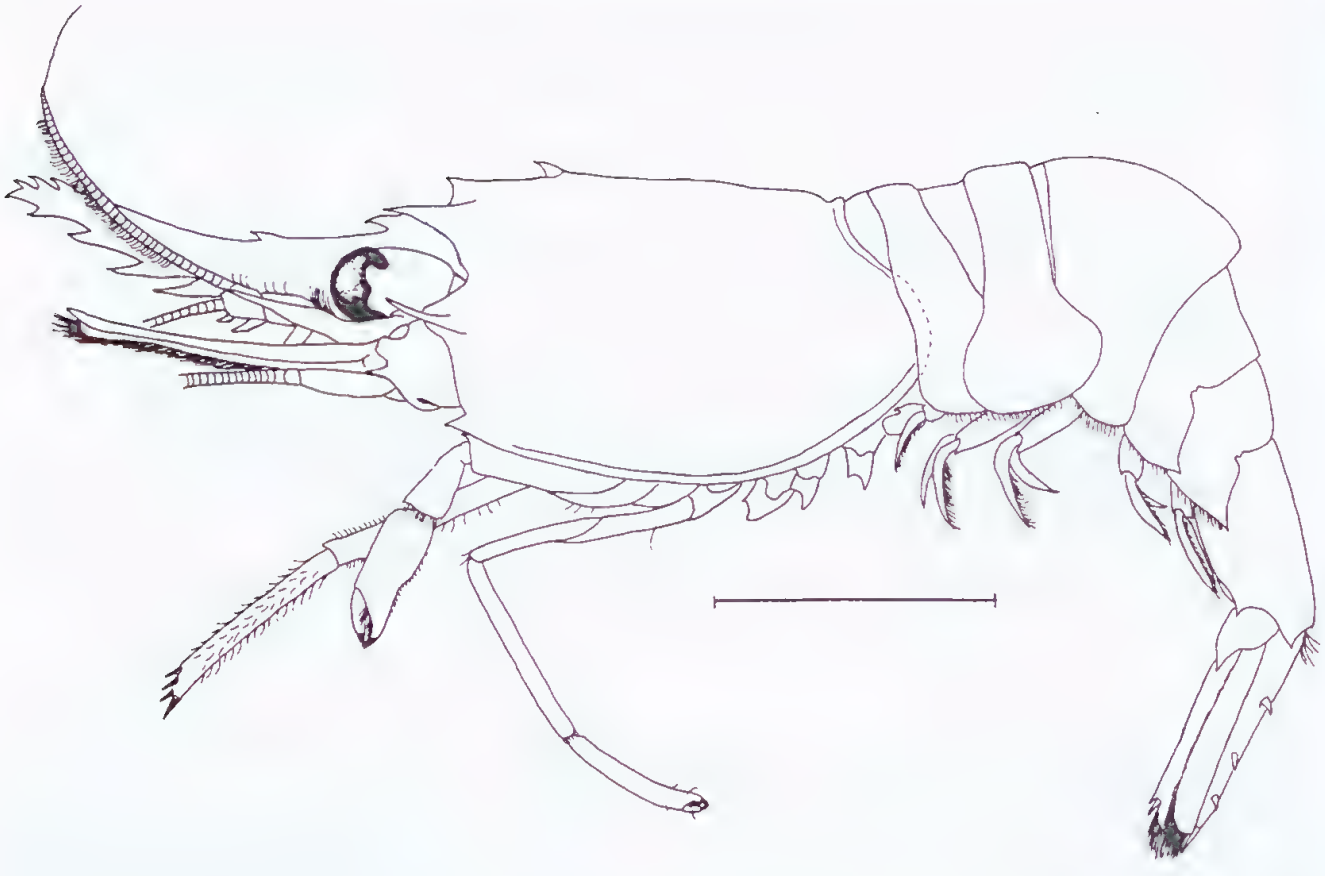

FIGURE 1. *Rhynchocinetes enigma* sp. nov., holotype male (SAM C5599, 6.8 mm CL). Scale bar = 5 mm.

two teeth in the basal half, and with three small teeth subterminally; ventral margin armed with eleven teeth, large proximally, elongate, decreasing distally.

Abdominal somites (Fig. 1) covered with fine striae; first three somites with the pleuron marginally rounded; pleura of fourth and fifth somites with distinct posteroventral tooth; sixth somite 0.48 – 0.50x as long as carapace, with acute posteroventral spine, with strongly hooked anal spine between bases of uropods, directed posteriorly. Telson (Fig. 2B) 0.57 – 0.63x as long as carapace, 1.16 – 1.30x as long as sixth abdominal somite, armed dorsally with three pairs of spines; midpoint of posterior margin triangularly produced, with three pairs of spines, median pair longest.

Eyes well developed, with large, globular cornea; stalk much more slender than cornea.

Antennular peduncle (Fig. 2C) reaching midlength of scaphocerite; stylocerite long, reaching or slightly shorter than level of distal margin of antennular distal segment; proximal segment with distolateral spine reaching distal margin of antennular median segment and small proximal lateral tooth, ventrally with acute spine at mesial margin; thickened part of upper antennular flagellum slightly overreaching rostral apex.

Antenna (Fig. 2D) with scaphocerite 0.84 – 0.93x as long as carapace, 4.20x as long as maximum width, distolateral spine acute, distinctly overreaching end of lamella; carpocerite reaching proximal quarter length of scaphocerite; basicerite with acute ventrolateral spine and with rounded protrusion just above the spine.

Mandible (Fig. 3A) with robust three-segmented palp, distal segment rounded, with dense setae marginally; incisor process well developed, with six marginal teeth; molar process obliquely truncate distally, with finely ridged distal end.

First maxilla (Fig. 3B) with slender palp armed distally with single long stout spiniform setae; proximal endite distinct, rounded, marginally with numerous setae; distal endite armed with ten stout spines on mesial margin.

Second maxilla (Fig. 3C) with well developed tapering palp; proximal endite slightly truncate; distal endite bilobed, upper lobe rather broader than lower lobe; scaphognathite large, overreaching level of tip of palp, anterior lobe with

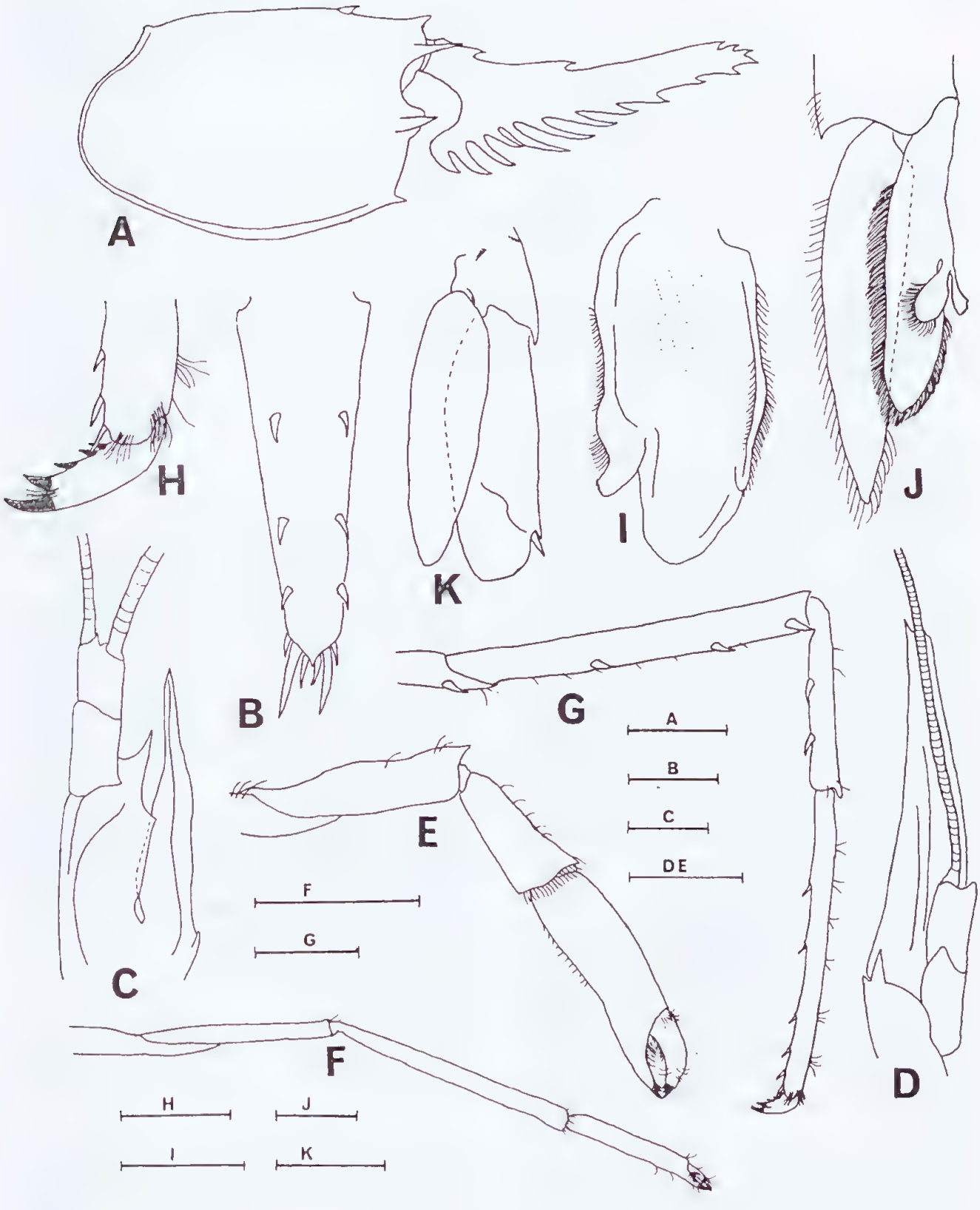

FIGURE 2. *Rhynchocinetes enigma* sp. nov., holotype male (SAM C5599, 6.8 mm CL). **A**, carapace with rostrum; **B**, telson, dorsal aspect; **C**, right antennular peduncle, dorsal aspect; **D**, right antenna, ventral aspect; **E**, right first pereiopod; **F**, right second pereiopod; **G**, right third pereiopod; **H**, same dactylus; **I**, endopod of right first pleopod; **J**, right second pleopod; **K**, right uropod, dorsal aspect. Scale bars; A = 2.5 mm; B, C = 1 mm; D, K = 2 mm; E, G = 1.5 mm; F = 3 mm; H–J = 0.5 mm.

TABLE 1. *Rhynchocinetes enigma*, new species. Branchial formula.

	Maxillipeds			Pereiopods				
	I	II	III	I	II	III	IV	V
Pleurobranchs	–	–	–	1	1	1	1	1
Arthrobranchs	–	–	–	–	–	–	–	–
Podobranchs	–	1	–	–	–	–	–	–
Epipods	1	1	1	1	1	1	1	–
Exopods	1	1	1	–	–	–	–	–

feebly quadrate distal end, posterior lobe tapering, with elongate plumose setae posteriorly, mesial margin convex.

First maxilliped (Fig. 3D) with endites distinctly separated, distal endite concave marginally, distinctly larger than proximal endite with slightly rounded margin; palp long, apparently two-segmented; exopod with long flagellum, caridean lobe distinct.

Second maxilliped (Fig. 3E) with well developed podobranch; epipod slightly pointed distally; exopod well developed, tapering; dactylar segment with truncate distal margin; propodal segment with external margin rounded, mesial margin expanded; ischiomeral segment distinct.

Third maxilliped (Fig. 3F) slightly shorter than tip of scaphocerite; exopod slightly shorter than distal margin of antepenultimate segment, tapering, with dense long setae; ultimate segment with six spines terminally, 0.59 – 0.62x as long as carapace, 2.00 – 2.24x as long as penultimate segment; penultimate segment 0.28 – 0.29x as long as carapace.

Branchial formula as shown in Table 1.

First pereiopod (Fig. 2E) chelate, moderately robust, falling slightly short of midlength of scaphocerite; chela 0.44 – 0.45x as long as carapace, 2.00 – 2.24x as long as carpus, tips of both fingers with dark terminal claws; carpus 0.21 – 0.25x as long as carapace, with acute spine at distal end of dorsal margin; merus dorsodistally acute.

Second pereiopod (Fig. 2F) chelate, much more slender than first pereiopod, reaching distal sixth of length of scaphocerite; chela 0.40x as long as carapace; carpus entire, 0.59 – 0.65x as long as carapace, 1.50 – 2.03x as long as chela.

Third pereiopod (Fig. 2G) reaching distal end of scaphocerite; ischium with single spine; merus 0.74 – 0.81x as long as carapace, 1.50 – 2.03x as long as carpus, with three almost equidistant spines; carpus 0.37 – 0.41x as long as carapace, with two spines on outer surface; propodus 0.69x as long as carapace, 1.68x as long as carpus, with about six short spinules on flexor margin; dactylus (Fig. 2H) with four accessory claws posterior to terminal largest claw, decreasing in size proximally.

Fourth pereiopod reaching distal fifth of length of scaphocerite, spinulation resembling that of third pereiopod; merus 0.67 – 0.72x as long as carapace, 1.86 –1.94x as long as carpus; carpus 0.34 – 0.38x as long as carapace; propodus 0.69x as long as carapace, 1.81x as long as carpus.

Fifth pereiopod slightly shorter than midlength of scaphocerite; spinulation resembling those of two anterior ambulatory pereiopods; merus 0.56 – 0.62x as long as carapace, 1.57 –1.72x as long as carpus; carpus 0.32 – 0.37x as long as carapace; propodus 0.58 – 0.66x as long as carapace, 1.79 – 1.80x as long as carpus.

Endopod of male first pleopod (Fig. 2I) with distal end rounded; well developed appendix interna at midlength of mesial margin, distal end of appendix with dense cincinnuli; distinct lobe at distal third of outer margin of endopod.

Endopod of male second pleopod (Fig. 2J) with appendices masculina and interna at distal two fifths of outer margin; appendix masculina broad, with distal margin rounded, fringed with dense setae; appendix interna considerably more slender and shorter than appendix masculina, with dense cincinnuli at distal end.

Uropodal exopod and endopod (Fig. 2K) slightly overreaching distal end of telson, exopod with a fixed and a movable spine at distal fifth of outer margin, the former considerably shorter than the latter.

Coloration

Unknown.

Distribution

Known only from the Great Australian Bight.

Discussion

Most rhynchocinetid shrimps are found around coral or rocky reefs in shallow waters, although three species, *R. australis* Hale, 1941, *R. balssi* Gordon, 1936 and *R. ikatere* Yaldwyn, 1971 are known from deep waters at depths in excess of 100 m (Hale 1941, Yaldwyn 1971, Holthuis 1972). The present new species represents the fourth rhynchocinetid shrimp obtained from such deep waters. Okuno (1996a) suggested that the

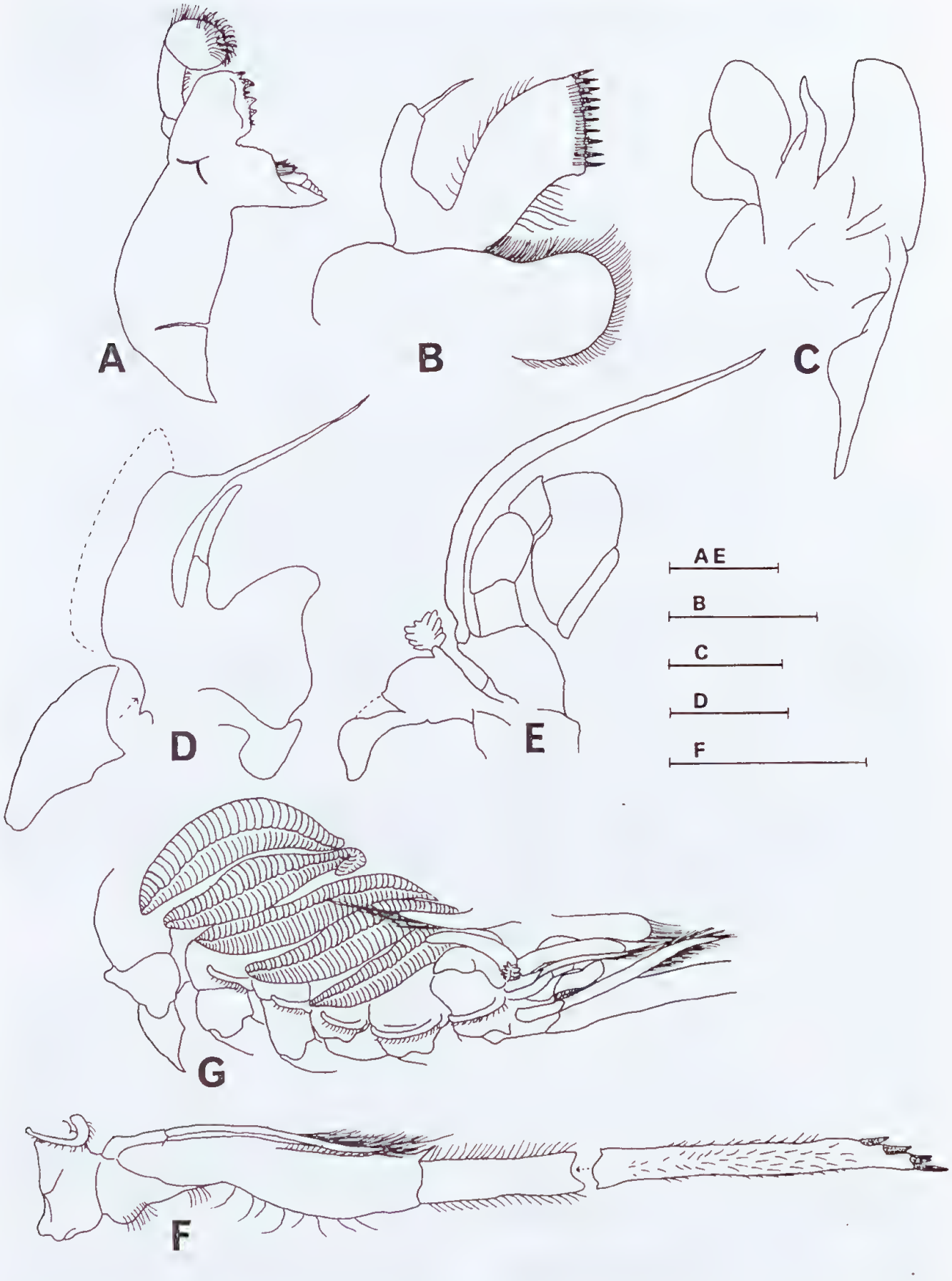

FIGURE 3. *Rhynchocinetes enigma* sp. nov., paratype male (SAM C5600, 7.6 mm CL). **A**, right mandible; **B**, right first maxilla; **C**, right second maxilla; **D**, right first maxilliped; **E**, right second maxilliped; **F**, right third maxilliped; **G**, right branchial region. Setae omitted on C, D, E. Scale bars; A–E = 1 mm; F = 2 mm; G = 3 mm.

TABLE 2. Specific list of *Rhynchocinetes* accompanied with number of arthrobranch (max. = maxilliped; per. = pereiopod).

	3rd max.	1st per.	2nd per.	3rd per.	4th per.	5th per.
R. australis Hale	2	1	1	–	–	–
R. balssi Gordon	2	1	–	–	–	–
R. brucei Okuno	2	1	1	1	–	–
R. conspiciocellus Okuno et Takeda	2	1	1	–	–	–
R. durbanensis Gordon	2	1	1	1	–	–
R. enigma sp. nov.	–	–	–	–	–	–
R. ikatere Yaldwyn	2	1	1	–	–	–
R. kuiteri Tiefenbacher	2	1	1	1	–	–
R. rathbunae Okuno	2	1	1	1	–	–
R. serratus (H. Milne-Edwards)	2	1	1	1	–	–
R. typus H. Milne-Edwards	2	1	1	1	1	–
R. uritai Kubo	2	1	1	–	–	–

temperate and subtropical *Rhynchocinetes* species all have a limited distributional range. Therefore, *R. enigma* probably occurs in southern Australian waters only.

Eleven species belonging to the genus *Rhynchocinetes* were previously known (Okuno 1996a). *Rhynchocinetes enigma* differs distinctly from the other species by the absence of an arthrobranch on all the maxillipeds and pereiopods (Fig. 3G). The other *Rhynchocinetes* species always have two small arthrobranchs on the third maxilliped and a developed arthrobranch on at least the first pereiopod (Table 2). In both *Rhynchocinetes* and *Cinetorhynchus*, the number of arthrobranchs varies at the species level (see Table 2; Okuno 1996b), and except for the number of arthrobranchs, there is no unique morphological character that distinguishes the new species from other *Rhynchocinetes* species. Therefore, I am inclined to place the new species in *Rhynchocinetes*, rather than establishing a new genus to accommodate it.

Etymology

The species name *enigma* refers to the enigmatical status within the genus, because of the absence of all arthrobranchs.

Acknowledgments

I am grateful to Ms K. Gowlett-Holmes for sending me the specimens on loan. I also thank Dr L. B. Holthuis for critically reading the manuscript and giving me valuable suggestions.

References

GORDON, I. 1936. On the macruran genus *Rhynchocinetes*, with description of a new species. *Proceedings of the Zoological Society of London* 1936: 75–88.

HALE, H. M. 1941. Decapod Crustacea. *B. A. N. Z. Antarctic Research Expedition 1929–1931, Reports-Series B* (Zoology and Botany) 4(9): 257–286.

HOLTHUIS, L. B. 1972. The Crustacea Decapoda Macrura (the Alpheidae excepted) of Easter Island. *Zoologische Mededelingen, Leiden* 46: 29–54, 2 pls.

OKUNO, J. 1996a. *Rhynchocinetes rathbunae*, a new shrimp from the Hawaiian Islands (Crustacea: Decapoda: Rhynchocinetidae). *Pacific Science* 50(3): 309–316.

OKUNO, J. 1996b. *Cinetorhynchus manningi*, a new shrimp (Crustacea: Decapoda: Caridea: Rhynchocinetidae) from the western Atlantic. *Proceedings of the Biological Society of Washington* 109(4): 725–730

OKUNO, J. in press. Review on the genus *Cinetorhynchus* Holthuis, 1995 from the Indo-West Pacific (Caridea: Rhynchocinetidae). *in* 'Le Benthos des Fonds Meubles des Lagons de Nouvelle-Calédonie'. Études et Thèses, Ed. B. Richer de Forges, ORSTIOM, Paris.

YALDWYN, J. C. 1971. Preliminary descriptions of a new genus and twelve new species of natant decapod crustacea from New Zealand. *Records of the Dominion Museum* 7: 85–94.

POMPHORHYNCHUS HERONENSIS SP. NOV. (ACANTHOCEPHALA: POMPHORHYNCHIDAE) FROM *LUTJANUS CARPONOTATUS* (LUTJANIDAE) FROM HERON ISLAND, AUSTRALIA

SYLVIE PICHELIN

PICHELIN, S. 1997. *Pomphorhynchus heronensis* sp. nov. (Acanthocephala: Pomphorhynchidae) from *Lutjanus carponotatus* (Lutjanidae) from Heron Island, Australia. *Records of the South Australian Museum* **30**(1): 19–27.

Pomphorhynchus heronensis sp. nov. is described from *Lutjanus carponotatus* (Lutjanidae) from Heron Island, Australia. The new species can be distinguished easily from all other species of the genus by the combination of the following characters: a relatively short neck with a symmetrical bulb (bulb/total neck length ratio = 1: 0.5), 15–17 longitudinal rows with 13–16 hooks per row of which the apical hooks (7–8 per row) have roots and are larger than the basal hooks and are arranged in slightly spiral rows whereas the basal hooks (6–8 per row) have no roots and are arranged in straight rows, a proboscis receptacle that does not extend beyond the bulb and atypical cement glands. This is the first species of *Pomphorhynchus* described from Australia and represents one of the few species of that genus known from a marine host.

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Manuscript received 29 April 1996.

There are four genera of Pomphorhynchidae: *Pomphorhynchus* Monticelli, 1905, *Longicollum* Yamaguti, 1935, *Tenuiproboscis* Yamaguti, 1935 and *Paralongicollum* Amin, Bauer and Sidorov, 1991. Of these, only species of *Longicollum* have been recorded in Australia (Edmonds 1989, Roubal 1993). There are about 25 species of *Pomphorhynchus* (see Amin 1985, Ortubay *et al.* 1991, Wang & Guo 1983). This study describes a new species of *Pomphorhynchus* from *Lutjanus carponotatus* (Lutjanidae) from Heron Island, Australia.

Materials And Methods

Twelve *Lutjanus carponotatus* were collected using handlines in the Wistari Channel, Heron Island and dissected for parasites. Acanthocephalans were removed from the intestine; host tissue surrounding the neck including the bulb of the worms was removed using micropins and forceps. Specimens were placed in a cavity block in tap water and refrigerated to encourage the eversion of the proboscis and then fixed in Berland's fluid and stored in 70% alcohol. Specimens were stained with Mayer's haematoxylin and mounted in Canada balsam. Lactophenol was used to clear specimens temporarily for description and measurement. Some worms were critical point dried, gold sputter-coated and examined under a scanning electron microscope operating at 5–10kV. Some worms were serially sectioned and stained with Mayer's haematoxylin and eosin. Drawings were made with the aid of a *camera lucida* and added to by hand. Measurements, presented as the range with the mean followed by the standard deviation in parenthesis, are given in micrometres; where measurements are presented in paired sets separated by a multiplication sign, the first figure is length, the second width. Sample size is given after each measurement. Type material has been deposited in the Australian Helminthological Collection (AHC), South Australian Museum.

Systematics

Class PALAEACANTHOCEPHALA

Family POMPHORHYNCHIDAE Yamaguti, 1939

Genus ***Pomphorhynchus*** Monticelli, 1905

Pomphorhynchus heronensis sp. nov.
(Figs 1–7)

Type host: *Lutjanus carponotatus* (Lutjanidae).
Other hosts: two specimens from intestine of 1 of

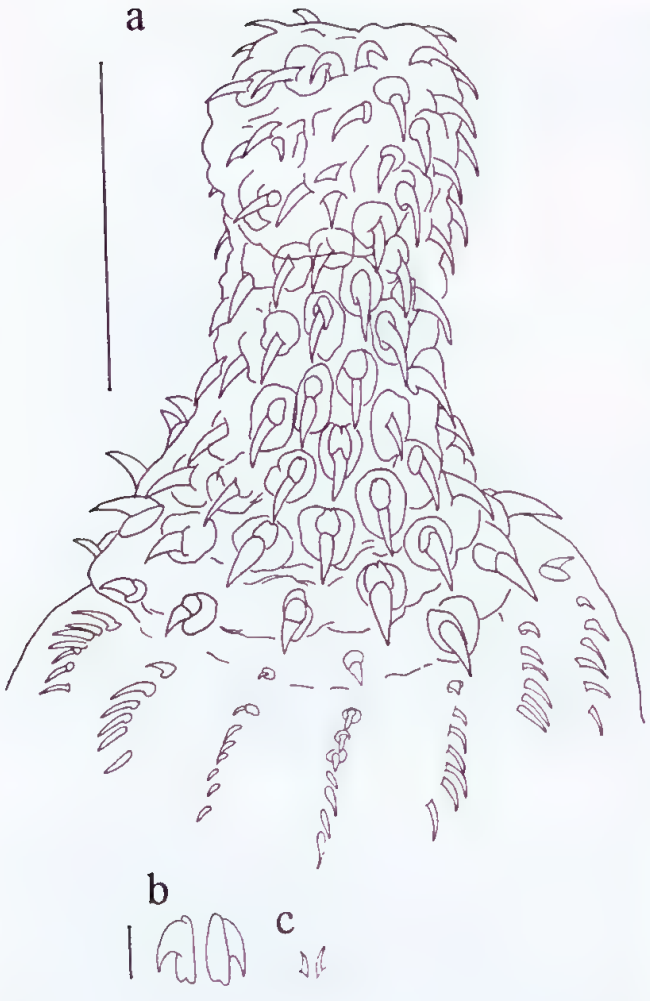

FIGURE 1. **a**, Proboscis showing two distinct hook types, **b**, apical hooks, and **c**, basal hooks on proboscis. Scale bars: a = 200, b and c = 20.

5 *Cheilinus trilobatus* (Labridae) from Heron I., Qld, Aust.
Type site: Rectum – neck and proboscis of parasites bulging through rectal wall into body cavity of host; infections easily diagnosed from outside gut.
Type locality: Heron I. (23°27' S, 151°55' E), Qld, Aust.
Material: holotype (male) AHC 30345; paratypes AHC 27665–27683, 30346.
Infection rate: 9 of 12 infected.

Description

General

Proboscis cone to pear shaped with slight anterior swelling; 2 distinct types of hooks (Figs 1a–c, 2) present. Apical proboscis hooks large 29.5–51.0 (43.2 ± s.d. 6.6) (n=19) (Fig. 1b); root 25.3–48.5 (39.6 ± s.d. 4.7) (n=15) with slight indentation of base; hooks arranged in 15–17 slightly spiralling rows of 7–8 hooks per row. Basal proboscis hooks small 14.8–23.5 (18.2 ± s.d. 2.3) (n=10) (Fig. 1c), slender with vestigial or no roots arranged in 15–17 straight rows of 6–8 hooks per row. Neck short (neck length: trunk length = 1: 0.32–0.61 (1: 0.44 ± s.d. 0.09) (n=20)), uniformly cylindrical from trunk level until abruptly swells to form symmetrical bulb encircling neck; bulb without protrusions or other irregularities, may be either spherical or slightly wider than long. Proboscis receptacle 923–1307 (1100 ± s.d. 123) x 161–231 (188 ± s.d. 23) (n=10) (Fig. 3) double walled, extends from base of proboscis to base of bulb; does not extend into trunk. Trunk widest anteriorly, tapering posteriorly. Lemnisci 2, slender, 980–2674 (1696 ± s.d. 702) (n=6) long.

Males

Total length 7780–13500 (10724 ± s.d. 2213) (n=15) (Fig. 4). Trunk 5520–10000 (7409 ± s.d. 1426) x 1000–2120 (1572 ± s.d. 357) (n=11) at widest point. Neck length including bulb 2250–3440 (2735 ± s.d. 522) (n=6); neck width excluding bulb 280–620 (392 ± s.d. 100) (n=10); bulb 950–1900 (1362 ± s.d. 369) (n=6) x 1360–2500 (1856 ± s.d. 441) (n=5); bulb/total neck length ratio 1: 0.42–0.59 (1: 0.5) (n=6). Lemnisci do not extend beyond anteriormost testis. Testes 2, ovoid, 360–840 (609 ± s.d. 124) x 246–520 (377 ± s.d. 90) (n=14), in tandem or diagonal, in anterior third of trunk. Cement glands number undetermined, probably 2 (Figs 5a–c); glands pyriform at level of seminal vesicle but become tubular and convoluted as they extend to posteriormost margin of testis. Proximal part of cement glands, seminal vesicle and Säfftigen's pouch contained within genital sheath (Fig. 5a); ligament sac envelops convoluted tubular part of cement glands, sperm duct and testes. Säfftigen's pouch pyriform, widest part measures 538 (n=1), thick-walled, partly enveloped by cement glands. Sperm duct emerges from seminal vesicle, runs anteriorly to testes; union of sperm duct and testes not seen. Seminal vesicle small, obscured by proximal part of cement glands. Bursa with pointed digitiform rays and 2 concentric rings of circumbursal receptors (Fig. 6).

Females

Total length 6630–14000 (9593 ± s.d. 2317) (n=21) (Fig. 7a). Trunk 4300–8540 (6157 ± s.d. 1194) x 1200–2960 (1761 ± s.d. 310) (n=16) at widest point. Neck length including bulb, 2000–3700 (2703 ± s.d. 445) (n=14); neck width

FIGURE 2. SEM of proboscis showing apical hook (arrow) and basal hook (arrowhead). Scale bar = 50.

excluding bulb 300–500 (373 ± s.d. 42) (n=14); bulb 900–1900 (1333 ± s.d. 350) x 1250–2400 (1699 ± s.d. 444) (n=16); bulb/total neck length 1: 0.41–0.59 (1: 0.50) (n=14). Female reproductive system consists of ovarian balls, ligament sac, uterine bell, uterus, well formed vaginal funnel, 2 consecutive vaginal sphincters and bulb (Fig. 7b); ligament sac broken in all specimens examined. Eggs ovoid to fusiform with small polar prolongations of middle membrane (Fig. 7c), 98–129 (112 ± s.d. 7) x 27–35 (33 ± s.d. 3) (n=15); eggs may be present in neck and bulb.

Discussion

The present specimens belong to the genus *Pomphorhynchus* according to acanthocephalan keys by Amin (1987a) and Amin *et al.* (1991) because they have a neck with a true bulb anteriorly and lack the spirally twisted neck which is characteristic of *Longicollum*.

The number of rows of hooks and the number of hooks per row are similar in most species of *Pomphorhynchus* including *Pomphorhynchus heronensis* sp. nov. However, all species of *Pomphorhynchus* except *P. heronensis* appear to

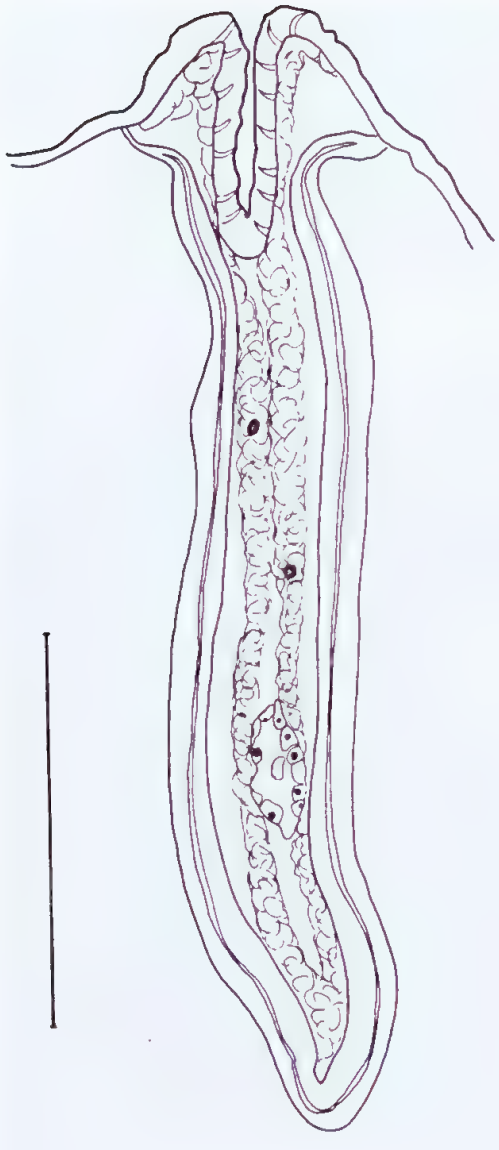

FIGURE 3. Horizontal section through the proboscis receptacle. Scale bar = 500.

have a proboscis receptacle that extends well beyond the bulb and, in many instances, into the trunk. The atypical shape and number of the cement glands in *P. heronensis* (see below) also distinguishes it from all other pomphorhynchid species. Further features that can differentiate this new species from other similar species of *Pomphorhynchus* are given below. The new species can further be differentiated from *P. patagonicus* Ortubay, Ubeda, Semenas and Kennedy, 1991, *P. sebastichthydis* Yamaguti, 1939 and *P. yamagutii* Schmidt and Hugghins, 1973 because they possess asymmetrical bulbs (Ortubay *et al.* 1991, Schmidt & Hugghins 1973, Yamaguti 1939). *Pomphorhynchus yunanensis* Wang, 1981 differs by having 12 rows of hooks with only 5–6 proboscis hooks per row (Wang 1981). *P. lucyi* Williams and Rogers, 1984 differs by having a considerably longer neck (Williams & Rogers 1984) relative to that of *P. heronensis*. *Pomphorhynchus cylindericus* Wang and Guo, 1983 and *P. bosniacus* Kiskároly and Čanković, 1969 have fewer than 15 rows of proboscis hooks with 9 or fewer hooks per row (Wang and Guo 1983, Kiskároly & Čanković 1969); also the testes of *P. cylindericus* are more posterior than those of *P. heronensis*. *Pomphorhynchus laevis* (Zoega in Müller, 1776) and *P. intermedius* Engelbrecht, 1957 have the last basal hooks on the proboscis

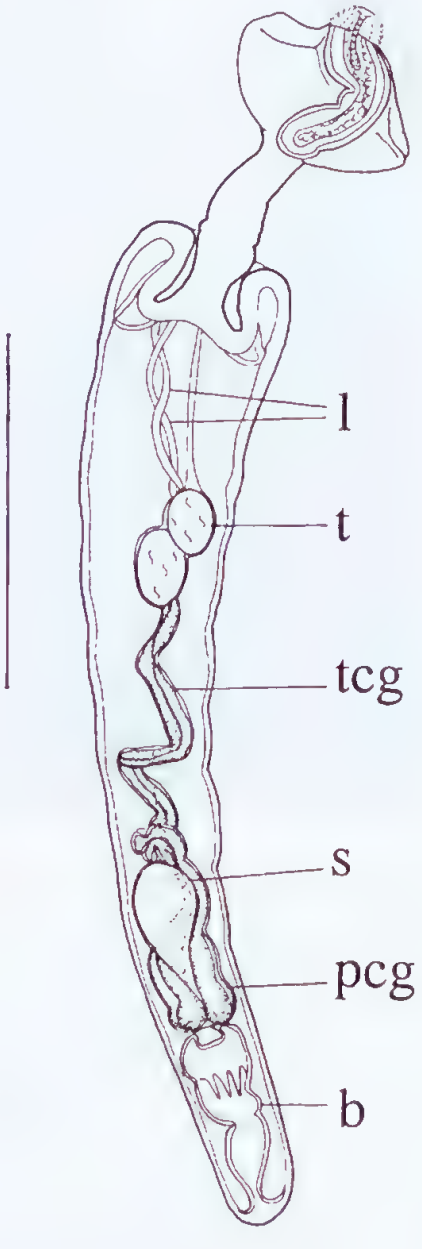

FIGURE 4. Male specimen (holotype), bulb slightly collapsed. Scale bar = 2000. Legend: l, lemnisci; t, testis; tcg, tubular part of cement glands; s, Säfftigen's pouch; pcg, posterior part of cement glands; b, bursa with bursal rays.

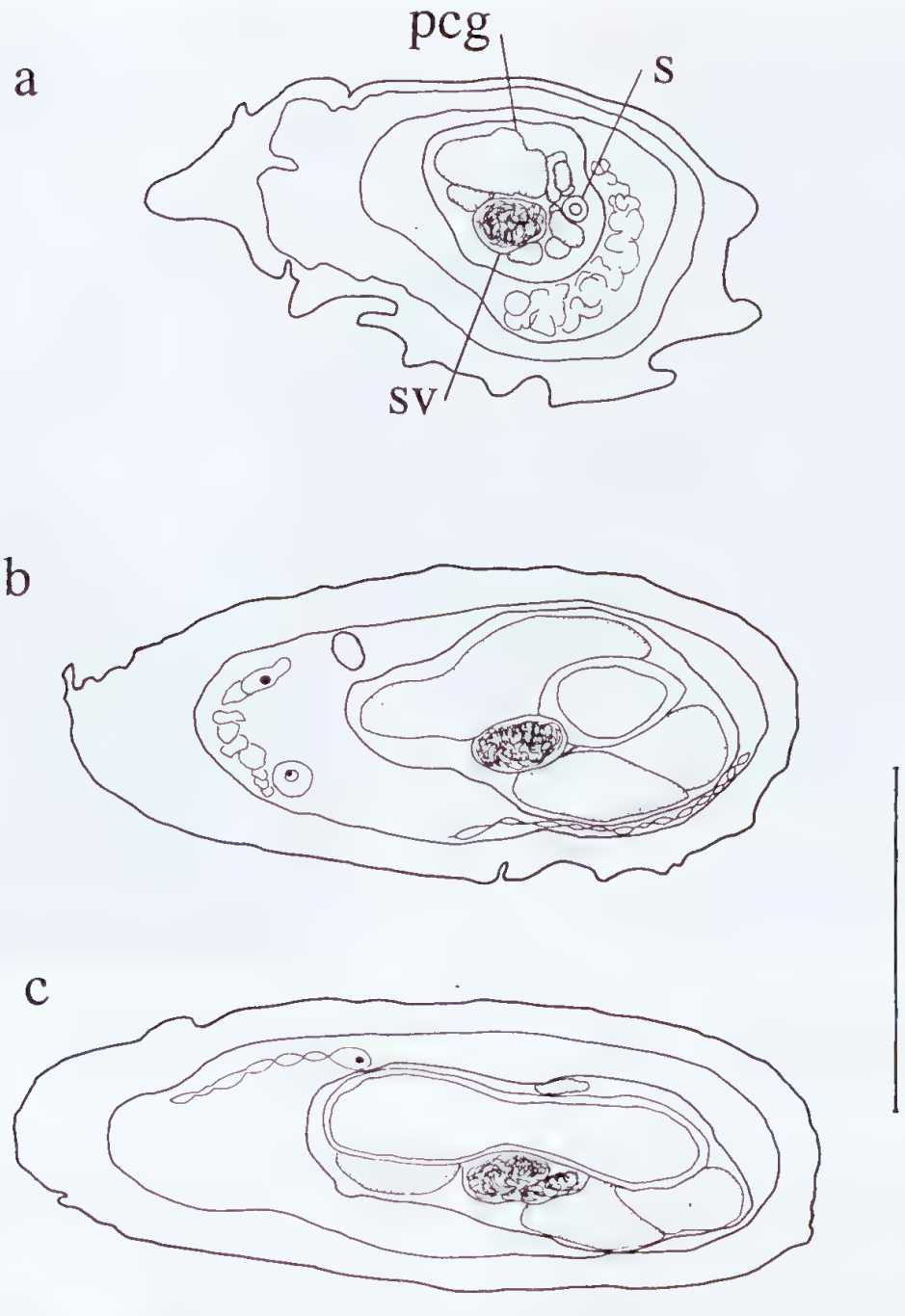

FIGURE 5. Transverse sections through a male specimen showing: **a**, the proximal ends of Säfftigen's pouch, cement glands and seminal vesicle; **b**, the cement glands partially enveloping Säfftigen's pouch (160μ further anterior from previous section); **c**, the widening of Säfftigen's pouch (70μ from previous section). Fig. 5a–c drawn to same scale. Scale bar = 500. Legend: s, Säfftigen's pouch; pcg, posterior part of cement glands; sv, seminal vesicle.

larger than those immediately preceding (Golvan 1969). *P. heronensis* does not have this feature; the last basal hook only appears longer when the other hooks of *P. heronensis* are not fully exposed. *P. intermedius*, like many other species of the genus, does not appear to possess the two very distinct sizes of hooks on the proboscis seen in the new species. Two distinct sizes of hooks can be seen on the proboscis of *P. laevis* as shown in Brown *et al.* (1986, Fig. 5) but in addition to the differences mentioned above *P. laevis* has fewer hooks per row (13–20 rows with 8–13 hooks) (Brown *et al.* 1986) than *P. heronensis*. Thus, the new species can be distinguished easily from all other species of the genus by the combination of the following characters: a relatively short neck with a symmetrical bulb (bulb/total neck length ratio 1:0.5; neck including bulb/trunk length ratio

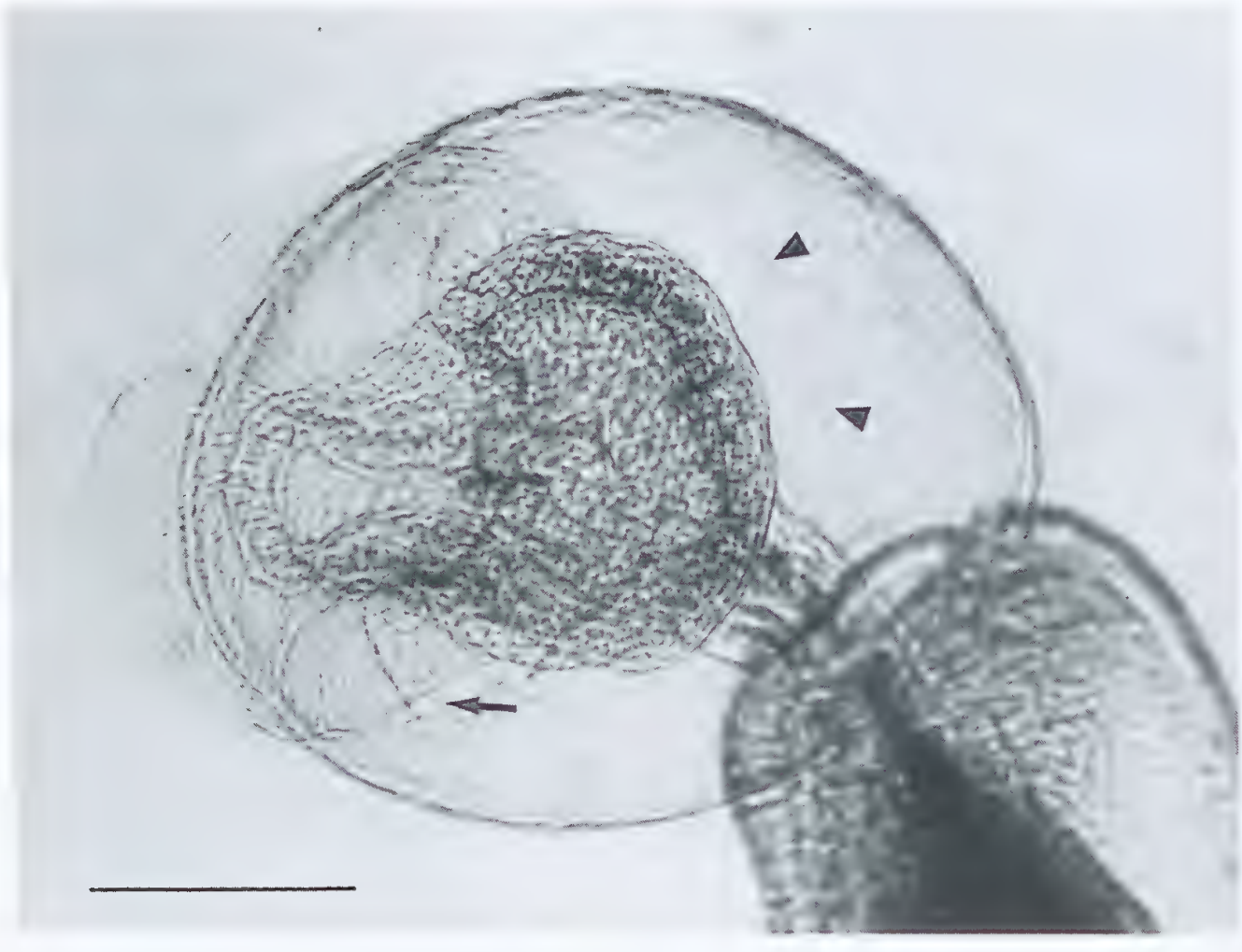

FIGURE 6. Light photomicrograph of cloacal bursa showing bursal rays (arrow) and two circles of circumbursal receptors (arrowheads). Scale bar = 250.

1:0.44), 15–17 longitudinal rows with 13–16 hooks per row of which the apical hooks (7–8 per row) have roots and are larger than the basal hooks and are arranged in slightly spiral rows whereas the basal hooks (6–8 per row) have no roots and are arranged in straight rows, a proboscis receptacle that does not extend beyond the bulb and atypical cement glands.

Some females, but not males, of the new species show deformities similar to those described by Amin *et al.* (1991) for specimens of *Paralongicollum nemacheili* Amin *et al.*, 1991. Other than the enlarged dorsal trunk region, deformed females did not appear to differ from normal females. Both normal and deformed females had eggs that were dispersed throughout the trunk and occasionally into the bulb; no eggs were present in the deformed part of the gravid female. The presence of eggs in the bulb seems uncommon in other pomphorhynchids but has been reported in *P. kashmirensis* Kaw, 1941 by Kaw (1941) and in *P. sebastichthydis* by Yamaguti (1939). The presence of eggs may well be an artefact of the method of fixing or preserving and is certainly not a useful taxonomic character.

The cement glands of *P. heronensis* appear atypical for the family. Normally, pomphorhynchids are said to have six cement glands. In this species however, there appear to be only two very long glands. A study of serial sections showed that the proximal part of the glands are pyriform and closely surround Säfftigen's pouch and the seminal vesicle. The glands then narrow out and run alongside the sperm duct up to the testes. Monorchic specimens of *P. heronensis* (n=2) appear to have the same arrangement of cement glands as normal males. Cement glands in species of *Pomphorhynchus* are not usually long but there is at least one other species, *Filisoma longcementglandatus* Amin and Nahhas, 1994, that has cement glands that may reach up to 16.00 mm in length (Amin & Nahhas,

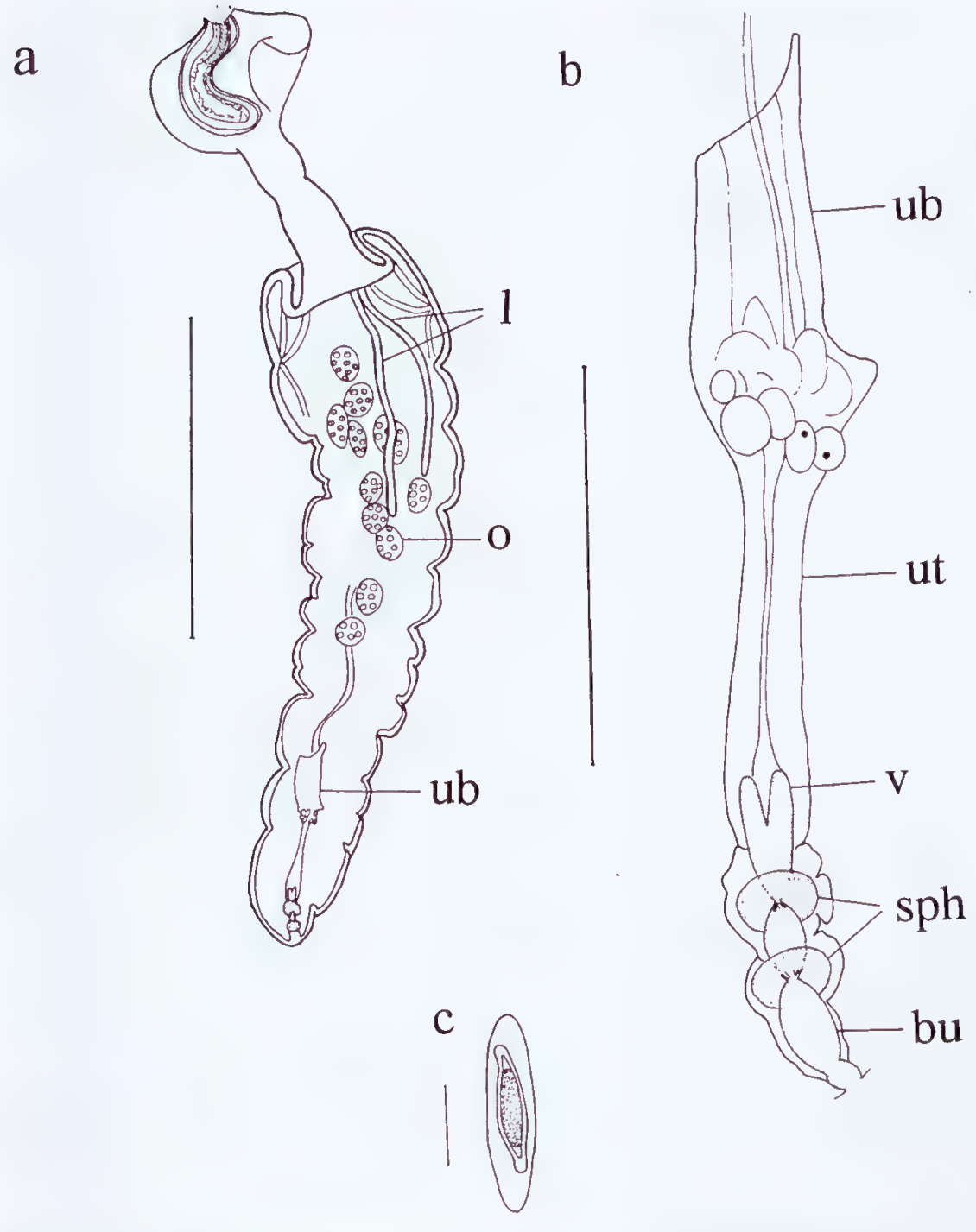

FIGURE 7.**a**, Female specimen, bulb slightly collapsed,**b**, uterine bell,**c**, egg. Scale bars: a = 2000, b = 500, c = 50. Legend: l, lemnisci; o, ovarian ball; ub, uterine bell; ut, uterus; v, vaginal funnel; sph, sphincters, bu, bulb.

1994). Why *P. heronensis* should have cement glands so different from other pomphorhynchids is unknown. It is proposed here that the generic diagnosis be amended to include the variable nature of the cement glands seen in *P. heronensis*.

Two circles of circumbursal receptors similar to those described by Brown (1987) were seen in one male specimen. Bursal rays were also noted in the same specimen. Neither circumpenial receptors nor muscular suckers in the bursa as those described by Brown (1987) and Doyle and Gleason (1991) could be seen in the new species. Although Brown (1987) considered the receptors may be useful taxonomically, these structures were not used as such in this paper because they were difficult to see. Brown (1987, Fig. 3) also showed the presence of vesicles in the bursa. However, Doyle and Gleason (1991) reported muscular suckers on the inner bursal surface and suggested that the vesicles noted by Brown (1987)

could have been a ballooning out of the muscular suckers caused by the method of preparation. A male with an hyperextended bursa would probably not be able to hold the female in position and thus fail to copulate.

Many acanthocephalans show size dimorphism; noteworthy is that both males and females of *P. heronensis* appear to be the same length. Also, there appeared to be an absence of very young stages. Although some juvenile pomphorhynchids appear able to detach from the gut, move and reattach to another region (Amin 1987b) no pomphorhynchids in the present study were found other than in the rectum. The lack of juvenile stages may indicate that hosts are not continuously infected throughout the year or that there is some mechanism restricting establishment of new parasites. Brown (1986) provided evidence to show that populations of *P. laevis* could reach a ceiling level and that parasite establishment could be density-dependent. However, in some cases it appears that this ceiling level is not reached because the critical resource, e.g. space, is only limited briefly (Bates & Kennedy 1991).

Pomphorhynchids have been recorded from a wide range of teleosts (see Golvan & de Buron 1988). Amin (1987c) recognised three categories of hosts for *P. bulbocolli* Linkins in Van Cleave, 1919: principal, accessory and occasional hosts. In this study, *L. carponotatus* is considered as a principal host for *P. heronensis* because female pomphorhynchids with ovarian balls, immature and mature shelled acanthors were regularly recovered, all parasites were firmly attached and none were found extraintestinally. This is consistent with the findings by Brown *et al.* (1986) and Amin (1987c) who considered the regular presence of mature gravid females as an indication that the parasite is in its preferred definitive host. It is also consistent with the observations made by Kennedy (1984) that *P. laevis* in its non-preferred hosts were smaller, immature, weakly attached and many were recovered in extraintestinal sites.

Most species of *Pomphorhynchus* occur in freshwater fishes. Some exceptions such as *Pomphorhynchus laevis* have been recorded from both freshwater and marine fishes (see, for example, Kennedy 1984). Although, it has been suggested that the freshwater *P. laevis* is a different strain from the marine *P. laevis* and that each strain has a preferred host (see Kennedy 1984); currently there is thought to be three strains (see Kennedy *et al.* 1989, Kennedy 1996). The preferred position in the preferred marine host of *P. laevis* is the rectum whereas the preferred position in freshwater host is more anterior (see Kennedy 1984). All the specimens of *P. heronensis* recovered for this study were found in the rectum of its host, *L. carponotatus*. *Lutjanus carponotatus* is not known from freshwater habitats (Allen & Talbot 1985) and thus the posterior position of the parasite cannot be correlated with a response to changing salinity as shown by Kennedy (1984) for *P. laevis* under certain circumstances.

Specimens of *Pomphorhynchus heronensis* were also recovered from one of five *Cheilinus trilobatus* in the present study and from one of five from another study of helminths in fishes of Heron Island (Cribb *pers. comm.*). In these specimens the parts of the worms that had penetrated the gut wall (i.e. the neck including the bulb) were decayed. Had this deterioration resulted from the worms being reproductively exhausted followed by death *in situ*, then worms in similar condition should have been found in *L. carponotatus*; none were. It may be that *C. trilobatus* is an unsuitable or at best an occasional host for *P. heronensis* but further material is needed to negate the possibility of other factors influencing the presence or absence of these parasites, such as the distribution of intermediate hosts and seasonality.

Acknowledgments

I am grateful to Dr T. H. Cribb for donating specimens of this species and reading this manuscript.

References

ALLEN, G. R. & TALBOT, F. H. 1985. Review of the snappers of the genus *Lutjanus* (Pisces: Lutjanidae) from the Indo-Pacific, with the description of a new species. *Indo-Pacific Fishes* **11**: 1–87.

AMIN, O. M. 1985. Classification. Pp. 27–72. *in* 'Biology of the Acanthocephala'. Eds. D. W. T. Crompton & B. B. Nickol. Cambridge: Cambridge University Press.

AMIN, O. M. 1987a. Key to the families and subfamilies of Acanthocephala, with the erection of a new class

(Polyacanthocephala) and a new order (Polyacanthorhynchida). *Journal of Parasitology* **73**: 1216–1219.

AMIN, O. M. 1987b. Acanthocephala from lake fishes in Wisconsin: morphometric growth of *Pomphorhynchus bulbocolli* (Pomphorhynchidae). *Journal of Parasitology* **73**: 806–810.

AMIN, O. M. 1987c. Acanthocephala from lake fishes in Wisconsin: ecology and host relationships of *Pomphorhynchus bulbocolli* (Pomphorhynchidae). *Journal of Parasitology* **73**: 278–289.

AMIN, O. M., BAUER, O. N. & SIDOROV, E. G. 1991. The description of *Paralongicollum nemacheili* n. gen., n. sp. (Acanthocephala: Pomphorhynchidae) from freshwater fishes in Kazakh S.S.R. *Journal of Parasitology* **77**: 26–31.

AMIN, O. M. & NAHHAS, F. M. 1994. Acanthocephala of marine fishes off Fiji islands, with descriptions of *Filisoma longcementglandatus* n. sp., *Neorhadinorhynchus macrospinosus* n. sp. (Cavisomidae), and gravid females of *Rhadinorhynchus johnstoni* (Rhadinorhynchidae); and keys to species of the genera *Filisoma* and *Neorhadinorhynchus*. *Journal of Parasitology* **80**: 768–774.

BATES, R. M. & KENNEDY, C. R. 1991. Site availability and density-dependent constraints on the acanthocephalan *Pomphorhynchus laevis* in rainbow trout, *Oncorhynchus mykiss* (Walbaum). *Parasitology* **102**: 405–410.

BROWN, A. F. 1986. Evidence for density-dependent establishment and survival of *Pomphorhynchus laevis* (Müller, 1776) (Acanthocephala) in laboratory-infected *Salmo gairdneri* Richardson and its bearing on wild populations in *Leuciscus cephalus* (L.). *Journal of Fish Biology* **28**: 659–669.

BROWN, A. F. 1987. Anatomical variability and secondary sexual characteristics in *Pomphorhynchus laevis* (Müller, 1776) (Acanthocephala). *Systematic Parasitology* **9**: 213–319.

BROWN, A. F., CHUBB, J. C. & VELTKAMP, C. J. 1986. A key to the species of Acanthocephala parasitic in British freshwater fishes. *Journal of Fish Biology* **28**: 327–334.

DOYLE, L. R. & GLEASON, L. N. 1991. Suckers and other bursal structures of *Pomphorhynchus bulbocolli* and *Acanthocephalus dirus* (Acanthocephala). *Journal of Parasitology* **77**: 437–440.

EDMONDS, S. J. 1989. A list of Australian Acanthocephala and their hosts. *Records of the South Australian Museum* **23**: 127–133.

GOLVAN, Y. J. 1969. Systématique des Acanthocéphales (Acanthocephala Rudolphi 1801). Première Partie. L'Ordre des Palaecanthocephala Meyer 1931. Premier fascicule. La Super-famille des Echinorhynchoidea (Cobbold 1876) Golvan et Houin 1963. *Mémoires du Muséum National d'Histoire Naturelle, Série A* **57**: 1–373.

GOLVAN, Y. J. & DE BURON, I. 1988. Les hôtes des Acanthocéphales. II. – Les hôtes définitifs. 1. Poissons. *Annals de Parasitologie et Humaine Comparée* **63**: 349–375.

KAW, B. L. 1941. Studies on the helminth parasites of Kashmir. Part I. Description of some new species of the genus, *Pomphorhynchus* Monticelli (1905). *Proceedings of the Indian Academy of Sciences* **13**: 369–378.

KENNEDY, C. R. 1984. The status of flounders, *Platichthys flesus* L., as hosts of the acanthocephalan *Pomphorhynchus laevis* (Müller) and its survival in marine conditions. *Journal of Fish Biology* **24**: 135–149.

KENNEDY, C. R. 1996. Colonization and establishment of *Pomphorhynchus laevis* (Acanthocephala) in an isolated English river. *Journal of Helminthology* **70**: 27–31.

KENNEDY, C. R. BATES, R. M. & BROWN, A. F. 1989. Discontinuous distributions of fish acanthocephalans *Pomphorhynchus laevis* and *Acanthocephalus anguillae* in Britain and Ireland: an hypothesis. *Journal of Fish Biology* **34**: 607–619.

KISKÁROLY, M. & ČANKOVIĆ, M. 1969. *Pomphorhynchus bosniacus* nov. sp. aus Barben *Barbus barbus* (L.) des Save-Gebietes. *Zoologischer Anzeiger* **182**: 69–74.

ORTUBAY, S., UBEDA, C., SEMENAS, L. & KENNEDY, C. 1991. *Pomphorhynchus patagonicus* n. sp. (Acanthocephala: Pomphorhynchidae) from freshwater fishes of Patagonia, Argentina. *Journal of Parasitology* **77**: 353–356.

ROUBAL, F. R. 1993. Comparative histopathology of *Longicollum* (Acanthocephala: Pomphorhynchidae) infection in the alimentary tract and spleen of *Acanthopagrus australis* (Pisces: Sparidae). *International Journal for Parasitology* **23**: 391–397.

SCHMIDT, G. D. & HUGGHINS, E. J. 1973. Acanthocephala of South American fishes. Part 2. Palaeacanthocephala. *Journal of Parasitology* **59**: 836–838.

WILLIAMS, E. H. JR. & ROGERS, W. A. 1984. *Pomphorhynchus lucyi* sp. n. (Acanthocephala) from fresh and brackish waters fishes of the southeastern U.S. Gulf Coast. *Journal of Parasitology* **70**: 580–583.

WANG, P. 1981. Notes on some species of Acanthocephala from fishes of China. (In Chinese). *Acta Zootaxonomica Sinica* **6**: 121–130.

WANG, P. & GUO, Q. 1983. Studies on some species of helminths from freshwater fishes in Yunnan, China. (In Chinese). *Oceanologia et Limnologia Sinica* **14**: 92–103.

YAMAGUTI, S. 1939. 16. Studies on the helminth fauna of Japan. Part 29. Acanthocephala, II. *Japanese Journal of Zoology* **8**: 317–351.

FIELD IDENTIFICATION OF FEMALE LITTLE BROWN BATS *VESPADELUS* SPP. (CHIROPTERA : VESPERTILIONIDAE) IN SOUTH AUSTRALIA

L. F. QUEALE

QUEALE, L. F. 1997. Field Identification of female little brown bats *Vespadelus* spp. (Chiroptera: Vespertilionidae) in South Australia. *Records of the South Australian Museum* 30(1): 29–33.

Five morphologically similar species of little brown bats occur in South Australia; *Vespadelus finlaysoni*, *V. darlingtoni*, *V. regulus*, *V. baverstocki* and *V. vulturnus*. As males can be identified by the shape of their penes, the emphasis of this paper is on methods to differentiate the females of these similar species. Characters are listed here for identifying female *Vespadelus* bats, particularly for use in the field, using external measurements and geographic distribution data. *Vespadelus finlaysoni* and *V. darlingtoni* were found to be generally distinguished on size alone and *V. vulturnus* to be distinguished on a wing measurement ratio. *Vespadelus regulus* and *V. baverstocki* presented the greatest difficulty for identification. However this study shows that these two species can be distinguished 90% of the time. Areas of allopatry, parapatry and sympatry of species are also discussed.

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The bats once referred to as a single species of *Eptesicus (E. pumilus)* are now regarded as nine species of *Vespadelus* (Kitchener *et al.* 1987, Volleth & Tidemann 1991). This diversity has only recently been recognised and many of the species' morphologies are very similar, so that practical problems in the field of specimen identification have not yet been completely solved.

The current taxonomy follows Kitchener *et al.* (1987) who revised the genus using a combination of morphological features. Their conclusions were confirmed by allozyme electrophoresis (Adams *et al.* 1987) which showed a minimum of nine species. Males of the five South Australian species, *Vespadelus finlaysoni*, *V. darlingtoni*, *V. regulus*, *V. baverstocki* and *V. vulturnus*, can be unambiguously identified using penis glans morphology (Reardon & Flavel 1987) but a reliable method is not available for female morphology. Many of the characters used by Kitchener *et al.* (1987) were internal features and cannot be used for field identification. Geographic variation within species further complicates identification.

The aim of the present study was to provide simple field methods for identifying female *Vespadelus* spp. using external characters. Outside South Australia other workers have found that there is more overlap in forearm lengths between species (Tidemann 1981, Lumsden & Bennett 1995). I found that limiting this study to South Australia, the task of identification can be made easier. These methods will prove useful in other states, although because of geographical variation there may be some differences.

Materials And Methods

Initially, 127 adult female *Vespadelus* bats (9 *V. darlingtoni*, 11 *V. finlaysoni*, 50 *V. regulus*, 38 *V. baverstocki* and 15 *V. vulturnus*) from the spirit preserved mammal collection of the South Australian Museum were examined for this study. Adults were distinguished by ossification of wing bone epiphyses. Specimens in the collection were collected from widely separated localities to take account of regional variation within South Australia. Based on the results of previous investigations (Carpenter *et al.* 1978, McKean *et al.* 1978, Tidemann *et al.* 1981, Kitchener *et al.* 1987) and the ease of measurement and assessment, the following characters were selected for examination:

1) forearm (= radius) length
2) ratio of phalanx I to metacarpal length on digit III
3) geographic distribution
4) colour of skin and fur

Wing bone length measurements (to the nearest 0.1 mm) were taken, using dial calipers, from joint to joint (outside) when the joints were bent (see Reardon and Flavel 1987).

Distribution maps were compiled for each species using females that had been reliably identified by electrophoresis (n=45) and males identified by glans penes (n=133), following the method of Reardon and Flavel (1987).

General colour of skin and fur were also noted to aid identification.

To test the reliability of the characters described above, an additional 40 bats were analysed using electrophoresis of liver enzymes. The discriminating enzymes used were: aspartate aminotransferase, carbonate dehydratase, phosphogluconate dehydrogenase, dipeptidase, tripeptide aminopeptidase, glucose-6-phosphate isomerase, mannose-6-phosphate isomerase (see Adams *et al.* 1987).

Results And Discussion

Forearm Length

Forearm ranges of *Vespadelus* spp. from South Australia were smaller than those of Kitchener *et al.* (1987). Two size groups were evident (see also Kitchener *et al.* 1987): *Vespadelus finlaysoni* and *V. darlingtoni* were separated from other species by their greater forearm length (Table 1). Females of these two species exceded 33.0 mm whereas the other three were usually less than 33.0 mm. The three smaller species (*V. regulus*, *V. vulturnus* and *V. baverstocki*) form a species group which is referred to here as the '*regulus* complex'.

Within the '*regulus* complex' in South Australia there were two subgroups based on forearm length, with a larger species, *V. regulus*, and two smaller species, *V. baverstocki* and *V. vulturnus*. There was considerable overlap in forearm length between *V. baverstocki* and *V. vulturnus*. Among adult females, 90% of *V. regulus* had forearm lengths greater than 30.5 mm, while all *V. vulturnus* and 95% of *V. baverstocki* measured less than 30.5 mm. Fig. 1 shows the overlap in forearm length of females.

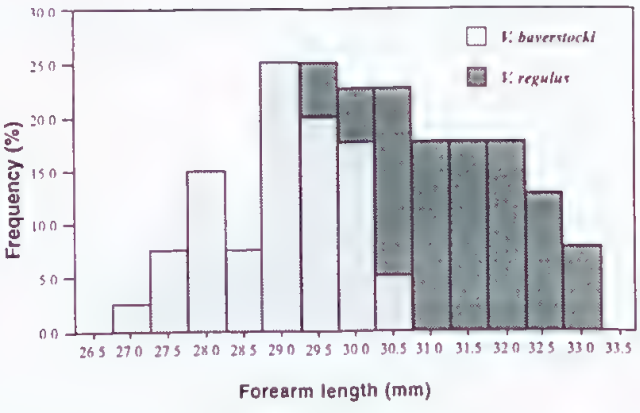

FIGURE 1. Size ranges in forearm length of female *V. baverstocki* and *V. regulus* in South Australia, showing the degree of overlap.

Ratio of Phalanx I: Metacarpal of Digit III

The ratio of phalanx I to the metacarpal on the third wing digit was used by Kitchener *et al.* (1987) to distinguish *V. vulturnus* from other species. Table 2 shows ratio ranges calculated for the three '*regulus* complex' species using only specimens identified by electrophoresis. Since sex does not affect this character (Kitchener *et al.* 1987), sexes were combined in the table. The data demonstrate a clear distinction between *V. vulturnus* (ratio ≥ 0.396) and the other two species (ratio ≤ 0.395) and confirm previous findings (Kitchener *et al.* 1987). *Vespadelus baverstocki* and *V. regulus* cannot be distinguished using this ratio.

Distribution and Habitat

Figs 2 to 6 show the geographical distribution of each species. Initially these maps were drawn using only bats that were identified by electrophoresis or penis morphology. Bats identified on wing measurements were examined later and all fell within the distribution ranges already recorded for the species. Habitat information has been taken from Carpenter *et al.* (1978) Reardon and Flavel (1987) and Lumsden and Bennett (1995).

TABLE 1. Means and ranges of forearm length (mm) of female *Vespadelus* species in South Australia.

Species	$\bar{x}$ SD	Range	n
V. darlingtoni	35.80±0.99	(34.7–38.1)	9
V. finlaysoni	34.45±0.86	(33.0–35.5)	11
V. regulus	31.37±1.14	(29.3–33.1)	50
V. baverstocki	29.12±0.95	(27.0–30.9)	38
V. vulturnus	28.47±1.24	(26.2–30.6)	15

TABLE 2. Range of ratios of phalanx I : metacarpal of digit III of *Vespadelus* spp. of the '*regulus* complex' in South Australia. Males and females included.

Species	Ratio	n
V. regulus	0.340–0.395	50
V. baverstocki	0.340–0.395	38
V. vulturnus	0.396–0.420	15

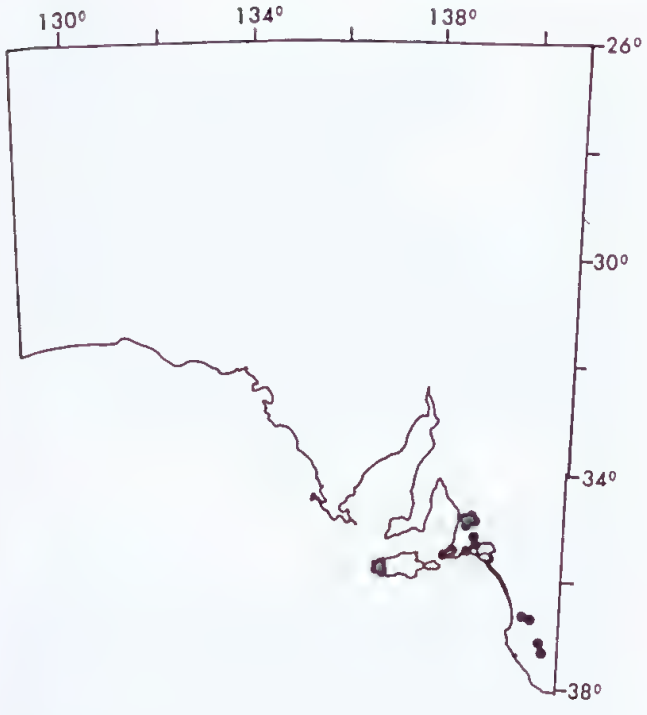

FIGURE 2. Distribution of *V. darlingtoni* in South Australia.

Vespadelus darlingtoni (Fig. 2) is confined to forested areas in the wetter southern and eastern regions of the State;

Vespadelus finlaysoni (Fig. 3) occurs in arid northern areas of South Australia in mountain ranges and rocky country in association with mines and caves;

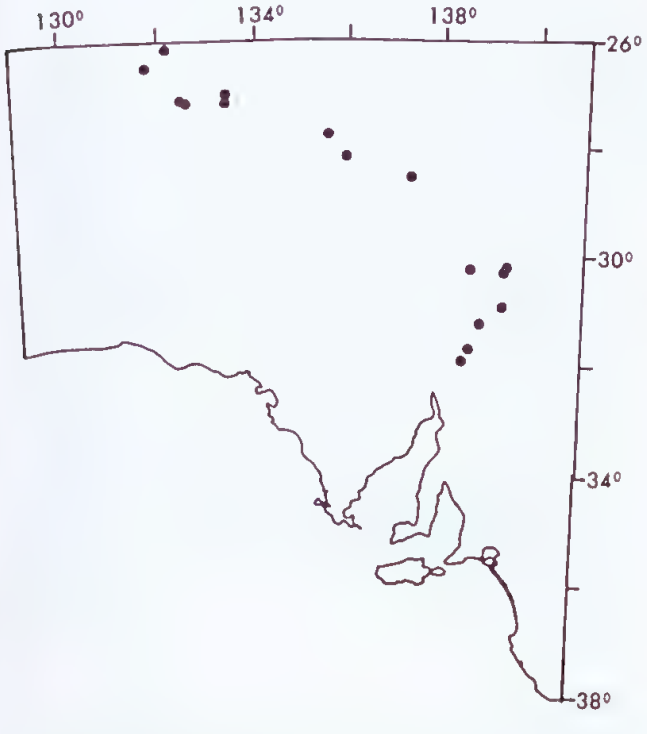

FIGURE 3. Distribution of *V. finlaysoni* in South Australia.

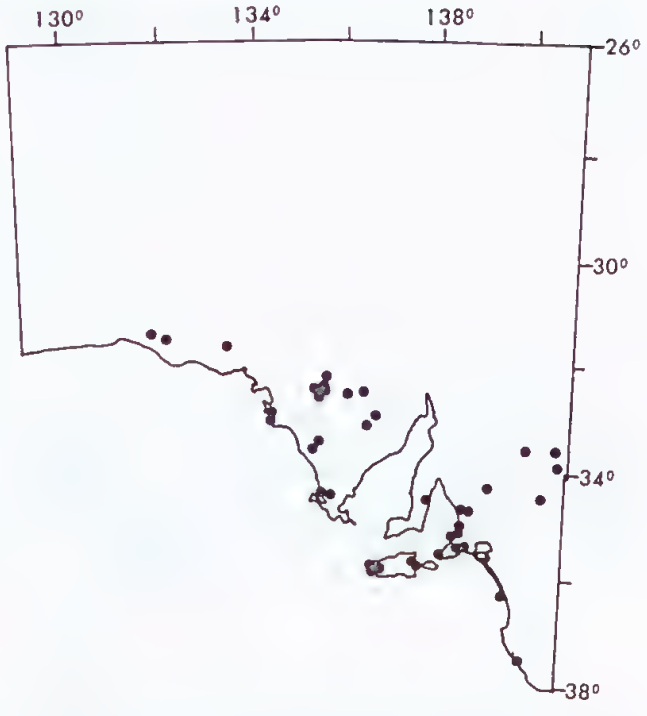

FIGURE 4. Distribution of *V. regulus* in South Australia.

Vespadelus regulus (Fig. 4) occurs in the south and east of South Australia in mallee woodlands and forests. It roosts in tree hollows and buildings. It is the only species found on Yorke and Eyre Peninsula;

Vespadelus baverstocki (Fig. 5) is found over a wide area in the arid and semi-arid woodlands and shrublands of the State and roosts in tree hollows and buildings;

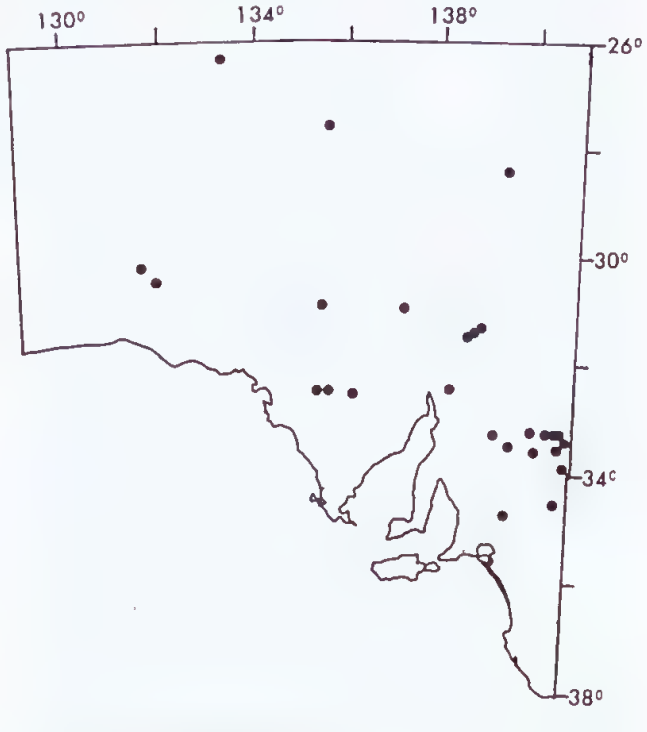

FIGURE 5. Distribution of *V. baverstocki* in South Australia.

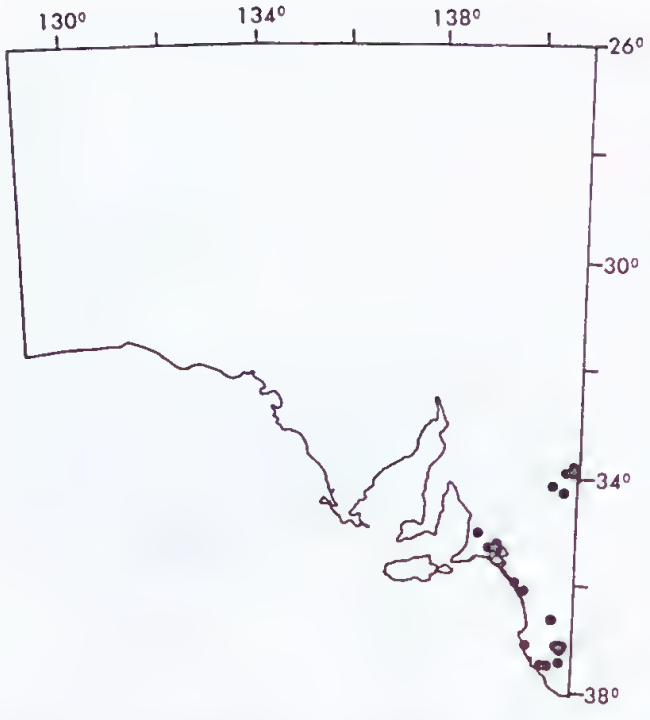

FIGURE 6. Distribution of *V. vulturnus* in South Australia.

Vespadelus vulturnus (Fig. 6) is found in woodlands and forests of the south-eastern region of the State, and along the River Murray. It roosts in tall trees along the River Murray and in the South East (Reardon & Flavel 1987).

Vespadelus regulus and *V. darlingtoni* are the only species of the genus to date recorded on Kangaroo Island.

There are several areas of sympatry for *Vespadelus* species in the State. The range of *V. finlaysoni* is shared with that of *V. baverstocki* (Figs 3 and 5) but the former species is not found in the regions occupied by the other two '*regulus* complex' species. The northern limits for *V. regulus* and the southern ranges of *V. baverstocki* overlap in central Eyre Peninsula and the Murray Mallee (Fig. 4). In this region it has been suggested that *V. baverstocki* prefers *Acacia* spp. open woodland and *V. regulus*, the mallee (C. Kemper, T. Reardon pers. comm., Lumsden and Bennett 1995). *Vespadelus vulturnus* inhabits wetter, tall forested areas. Considerable overlap occurs between all three '*regulus* complex' species in the River Murray region (Figs 4–6). Here a corridor of sympatry follows the 250 mm isohyet which coincides with the separation of eucalypt (mallee) and *Acacia* spp. woodland (Griffin & MacCaskill 1986) and the well-watered riverine eucalypt forest.

Colour

Differences in fur colour have been noted between *Vespadelus* species (McKean *et al.* 1978; Kitchener *et al.* 1987; Reardon & Flavel 1987). The fur of *V. darlingtoni* is very dark brown, as is the skin on the forearms. By contrast, the fur of *V. finlaysoni* is grey. The '*regulus* complex' species share a third colouration type in which the fur is bicoloured, the hairs having brown bases and pale tips. The ventral surface of the body is lighter than the dorsal surface. Hence colour is not useful for distinguishing between the species of the '*regulus* complex'.

Electrophoresis

To test the key (below) an additional sample of female bats, with accompanying frozen tissue, was identified using the key as 26 *V. baverstocki,* 10 *V. regulus* and four *V. vulturnus*. Then allozyme electrophoresis was performed on this sample. The allozyme comparisons confirmed that the morphological characters had correctly predicted the identifications of all 40 specimens. This confirmation indicates that despite overlap in some characters, the key can be used with confidence to distinguish the species.

Species summaries

Vespadelus darlingtoni may be easily distinguished from the '*regulus* complex' species by its greater size (forearm length) and from *V. finlaysoni* by its dark colour and distribution.

Vespadelus finlaysoni is similarly distinguished by its large size from the '*regulus* complex' species. There is a size overlap with *V. regulus* but there is no overlap in distribution.

Vespadelus vulturnus is separated from the two larger species, *V. finlaysoni* and *V. darlingtoni* on size, with no overlap in forearm measurements. A size overlap occurs rarely with *V. regulus* and more commonly with *V. baverstocki* and may be distinguished from these on the basis of the phalanx I: metacarpal ratio.

Vespadelus regulus may be distinguished from *V. darlingtoni* on size and colour, from *V. finlaysoni* on distribution and partly on size, and from *V. vulturnus* partly on size and wing ratios.

Vespadelus baverstocki can be readily distinguished on size from the two largest species, *V. finlaysoni* and *V. darlingtoni*. It can be separated from *V. vulturnus* on the basis of phalanx I: metacarpal ratio. In many cases it can be separated from *V. regulus* on size. When this is not successful electrophoresis must be employed.

KEY TO FEMALE *VESPADELUS* IN SOUTH AUSTRALIA

1. — Forearm greater than 33 mm 2
   Forearm less than 33 mm 3
2. — Latitude south of 33°S ..... *V. darlingtoni*
   Latitude north of 33°S ..... *V. finlaysoni*
3. — Ratio of phalanx I: metacarpal of digit III greater than 0.39; latitude south of 33°S ..... *V. vulturnus*
   Ratio of phalanx I: metacarpal of digit III less than 0.39; locality variable 4
4. — Forearm usually greater than 30.5 mm; mallee habitat/coastal or latitude south of 34°S ..... *V. regulus*
   Forearm usually less than 30.5 mm; arid habitat/inland or usually latitude north of 34°S ..... *V. baverstocki*

Note on males

Although males can be identified by penis morphology, this can prove difficult in the field. The characters discussed above can be used to identify males. However my data indicate that male forearms tend to be shorter than females.

TABLE 3. Ranges of forearm length (mm) of male *Vespadelus* species in South Australia.

Species	$\bar{x}$	SD	Range	n
V. darlingtoni	34.9	±0.51	(33.5–38.1)	14
V. finlaysoni	33.2	±0.64	(32.4–34.4)	13
V. regulus	30.3	±0.96	(28.5–33.1)	51
V. baverstocki	29.2	±0.96	(26.7–30.7)	29
V. vulturnus	27.7	±1.33	(25.2–29.5)	16

Thus the key can be used with some discretion as an aid in identification of males. The one exception is that the identification key and species summaries do not distinguish easily between male *V. regulus* and *V. baverstocki* on forearm lengths (see Table 3).

ACKNOWLEDGMENTS

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REFERENCES

ADAMS, M., BAVERSTOCK, P. R., WATTS, C. H. S. & REARDON, T. B. 1987. Electrophoretic resolution of species boundaries in Australian Microchiroptera. 1. *Eptesicus* (Chiroptera: Vespertilionidae). *Australian Journal of Biological Sciences* **40**: 143–162.

CARPENTER, S. M., McKEAN, J. L. & RICHARDS, G. C. 1978. Multivariate morphometric analysis of *Eptesicus* (Mammalia: Chiroptera) in Australia. *Australian Journal of Zoology* **26**: 629–638.

GRIFFIN, T. & MacCASKILL, M. (Eds) 1986. 'Atlas of South Australia'. South Australian Government Printer: Adelaide.

KITCHENER, D. J., JONES, B. & CAPUTI, N. 1987. Revision of Australian *Eptesicus* (Microchiroptera: Vespertilionidae). *Records of the Western Australian Museum* **13**: 427–500.

LUMSDEN, L. F. & BENNETT, A. F. 1995. Bats of a semi-arid environment in south-eastern Australia: biogeography, ecology and conservation. *Wildlife Research* **22**: 217–240.

McKEAN, J. L., RICHARDS, G. C. & PRICE, W. J. 1978. A taxonomic appraisal of *Eptesicus* (Chiroptera: Vespertilionidae) in Australia. *Australian Journal of Zoology* **26**: 529–537.

REARDON, T. B. & FLAVEL, S. 1987. 'A Guide to the Bats of South Australia'. South Australian Museum: Adelaide. 85pp.

TIDEMANN, C. R., WOODSIDE, D. P., ADAMS, M. & BAVERSTOCK, P. R. 1981. Taxonomic separation of *Eptesicus* (Chiroptera: Vespertilionidae) in southeastern Australia by discriminant analysis and electrophoresis. *Australian Journal of Zoology* **29**: 119–128.

VOLLETH, M. & TIDEMANN, C. R. 1991. The origin of the Australian Vespertilionidae bats, as indicated by chromosomal studies. *Zeitschrift für Saugetierkunde* **56**: 321–330.

FOUR NEW SPECIES OF *ANTIPORUS* SHARP (COLEOPTERA, DYTISCIDAE) FROM AUSTRALIA, WITH NOTES ON *A. FEMORALIS* (BOH.) AND *A. INTERROGATIONIS* (CLARK)

C. H. S. WATTS

WATTS, C. H. S., 1997. Four new species of *Antiporus* Sharp (Coleoptera, Dytiscidae) from Australia, with notes on *A. femoralis* (Boh.) and *A. interrogationis* (Clark). *Records of the South Australian Museum* **30**(1): 35–42.

Four new species of *Antiporus* are described from Australia: *A. jenniferae* sp. nov., *A. hollingsworthi* sp. nov., *A. willyamsi* sp. nov. and *A. pembertoni* sp. nov. The distribution of *A. femoralis* (Boh.) and *A. interrogationis* (Clark) in Australia is reviewed. A key to the Australian species is provided.

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Manuscript received, 28 February 1996.

The species of *Antiporus* were last revised by Watts (1978) who recognised six species. In 1984 Brancucci (1984) resurrected *A. interrogationis* (Clark) from synonymy with *A. femoralis* (Boh.). In this paper I take the opportunity to describe four additional species of *Antiporus* Sharp from Australia and to review the distribution of *A. femoralis* (Boh.) and *A. interrogationis.* One of the new species, *A. jenniferae*, is close to *A. simplex* Watts, one, *A. willyamsi*, has unusual sexual hairs on the front and middle trochanters and the other two belong to a group of dark coloured *Antiporus* with enlarged metafemora in the males (*A. femoralis, A. interrogationis, A. wilsoni* Watts, *A. hollingsworthi* n. sp. and *A. pembertoni* n.sp.). Males of this *A. femoralis* group are easily separated on the shapes of the metafemur, proclaw and aedeagus. Females are difficult to distinguish, other than *A. interrogationis* which can be recognised by the colour on the pronotum.

The new species are rare in collections, although this may in part reflect a lack of collecting particularly in south-west Australia.

The collections from which specimens were examined are listed under the following abbreviations:

AM Australian Museum, Sydney.
ANIC Australian National Insect Collection, Canberra.
BMNH Natural History Museum, London.
MV Museum of Victoria, Melbourne.
SAMA South Australian Museum, Adelaide.
WAM Western Australian Museum, Perth.
UQIC Entomology Department Queensland University, Brisbane.

Systematics

Key To Australian Species Of *Antiporus* Sharp

1 — Protarsus with 2 claws ..... Females 2
— Protarsus with 1 claw ..... Males 10

2 — Relatively large (> 6mm), predominantly reddish-yellow, elytra with 5–6 often incomplete long dark lines .... *A. gilberti* (Clark)
— Not with above combinations of characters 3

3 — Protarsi black. Relatively small (<4mm) .. .. *A. jenniferae* sp. nov.
— Protarsi reddish-yellow, same colour as rest of leg 4

4 — At least the basal segment of mesotarsi enlarged in comparison with protarsi 5
— Segments of mesotarsi similar to those on protarsi or smaller 6

5 — Elytron with small and large punctures, all mesotarsal segments larger than those of protarsi, elytra with lighter streaking in younger specimens ... *A. willyamsi* sp. nov
— Elytra with uniform punctuation, only basal segment of mesotarsi enlarged, elytra uniformly dark red-brown to black . ..... *A. wilsoni* Watts

6 — Smaller (< 3.5mm) 7
— Larger (>3.5mm) 8

7 — Elytron dark, usually with three reddish-yellow spots, pronotum reddish-yellow with dark front and rear borders .... *A. bakewelli* (Clark)

— Elytron and pronotum uniformly red-brown..... *A. simplex* Watts

8 — More or less uniformly dark reddish-brown, elytron tip often appears truncated ..... *A. blakei* (Clark)

— Elytra normally black with or without lighter markings. Tip of elytron pointed . 9

9 — Black portion in centre of pronotum not reaching front border .... *A. interrogationis* (Clark)

— Black portion in centre of pronotum reaching front border .... *A. hollingsworthi* sp. nov. (W.A. only), ?*A. pembertoni* sp. nov. (W.A. only, female unknown), *A. femoralis* (Boh.)

10 — Prominent cup-like tuft of long golden setae on mesotrochanters (Fig. 28). Segments of mesotarsus larger than segments of protarsi .... *A. willyamsi* sp. nov.

— Mesotrochanters without such a tuft of setae. Segments of mesotarsus smaller than those of protarsus 11

11 — Metafemur produced on inside near apex 12

— Metafemur simple 13

12 — Relatively large (>6 mm), predominantly reddish-yellow, elytron with several long black lines. Metafemur with prominent narrow triangular process on inside near apex ..... *A. gilberti* (Clark)

— Predominantly dark-brown to black. Metafemur broadly produced on inside near apex 16

13 — Larger (length > 4.5 mm). Mesotibia strongly triangularly produced in middle on outside ..... *A. blakei* (Clark)

— Smaller (length < 3.7 mm). Mesotibia simple or thickened and angular but never as above 14

14 — Protarsi black in contrast to red-brown colour of rest of leg .... *A. jenniferae* sp. nov.

— Protarsi reddish-brown, same colour as rest of leg 15

15 — Elytron unicolorous, except for slightly paler sutural region and sides. Metacoxal lines evenly diverging anteriorly. Claw on protarsus relatively straight, with small basal tooth (Fig. 21) .... *A. simplex* Watts

— Elytron with one or more pale patches. Metacoxal lines much less divergent in anterior quarter than in middle. Claw on protarsus sickle-shaped, with large basal tooth (Fig. 18) ..... *A. bakewelli* (Clark)

16 — *A. femoralis* complex. The species are best separated by characters of the aedeagus and metafemur given in Figs 1–15. In addition the black portion in the centre of the pronotum does not reach the front border in *A. interrogationis* whereas it does in the other species.

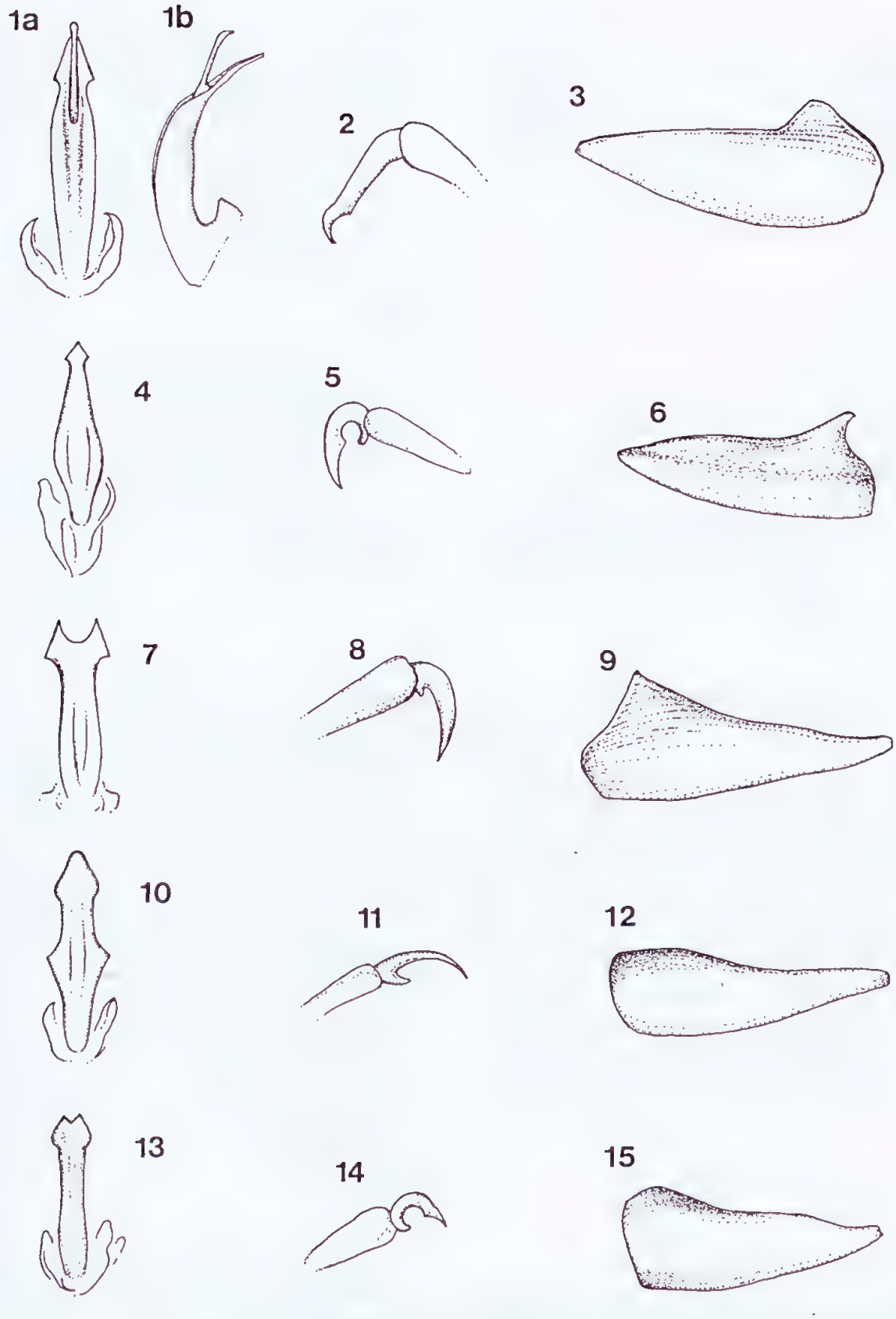
Antiporus femoralis (Boheman, 1858)
(Figs 7, 8 & 9)

Number examined, 83.

Brancucci (1984) clarified the relationships between this widespread and common species and *A. interrogationis* (Clark). It can be separated from this species by characters of the aedeagus and metafemur and in having the dark patch on the middle part of the pronotum reaching the anterior border. In this last character it is similar to the other members of the *A. femoralis* group. It differs from these in characters mentioned under the different species and illustrated in the figures.

Distribution

Australian Capital Territory: Black Mountain, ANIC; Hackett, ANIC; Mt Coree, ANIC; O'Connor, ANIC. **New South Wales:** Allyn River, ANIC; Galston, ANIC; Queanbeyan, ANIC; Sydney, MV, ANIC; Waratah, SAMA; Williams River, ANIC. **South Australia:** Beachport, AM; Eyre Peninsula, SAMA; Kangaroo Island, SAMA; Lucindale, SAMA; Port Lincoln, AM, SAMA. **Tasmania:** 11 km NNW Blackland, ANIC; Eaglehawk Neck, AM; Georgetown, MV; Hobart, MV; Launceston, MV; Liffey Valley, ANIC; Waldheim, UQIC. **Victoria:** 4 km W. Ballan, MV; L. Barracoota, MV; Cape Otway, MV;10 km NW Dartmouth Dam, MV; La Trobe, SAMA; L. Learmonth, ANIC;10 km NW



FIGURES 1–15. **1a**, dorsal view of aedeagus of *A. hollingsworthi*; **1b**, lateral view of aedeagus of *A. hollingsworthi* showing apical appendage; **2**, proclaw of male *A. hollingsworthi*; **3**, postfemur of *A. hollingsworthi*. **4**, dorsal view of aedeagus of *A. interrogationis*; **5**, proclaw of male *A. interrogationis*; **6**, postfemur of *A. interrogationis*. **7**, dorsal view of aedeagus of *A. femoralis*; **8**, proclaw of male *A. femoralis*; **9**, postfemur of *A. femoralis*. **10**, dorsal view of aedeagus of *A. pembertoni;* **11**, proclaw of male *A. pembertoni*; **12**, postfemur of *A. pembertoni*. **13**, dorsal view of aedeagus of *A. wilsoni*; **14**, proclaw of male *A. wilsoni*; **15**, postfemur of *A. wilsoni*.

Lexton, MV; Montmorency, SAMA; Mt Buffalo, MV; Mudgee, ANIC; Myrtleford, MV; Oakleigh, MV; Reservoir, MV; Werribee, MV. **Western Australia:** 9 mi NE by E Esperance, ANIC; Geraldton, MV; King George Sound, ANIC; Mullewa, SAMA; Ravensthorpe, ANIC; Stirling National Park, ANIC; Swan River, SAMA; Wilga, ANIC.

Antiporus interrogationis (Clark, 1862)
(Figs 4, 5 & 6)

Number examined, 62.

As pointed out by Brancucci (1984), *A. interrogationis* is clearly distinct from *A. femoralis* with which I had previously synonymised it (Watts 1978). Apart from the aedeagus (Fig. 4) and metafemur (Fig. 6), *A. interrogationis* differs from the other members of the *A. femoralis* group by the dark patch on the middle part of the pronotum usually not reaching the anterior border.

Distribution

Australian Capital Territory: Black Mountain, ANIC; Paddy's River, ANIC. **New South Wales:** 37 km E Hay, SAMA. **South Australia:** Naracoorte, UQIC. **Victoria:** 4 km W Ballan, MV; Bright, SAMA, MV, AM; Buninyong, MV; Delatite, MV; Delley's Dell Grampians, SAMA; Dividing Range, SAMA; Eltham, MV; Glen Valley, MV; Hamilton, MV; L. Purrumbete, MV; L. Wendouree, MV; Linga, MV; Melbourne, ANIC, MV; Merrimans Creek, MV; Mitta Mitta River, MV; Montmorency, SAMA; Mt Buffalo, SAMA; Nelson, SAMA; Noorinbee North, MV; Six Mile Creek Dartmouth, MV; 8 km NE Toolangi, MV; Warburton, MV; Werribee, MV; Yarra River, MV; Yarrawonga, MV.

Antiporus jenniferae sp. nov.
(Figs. 25, 26 & 27)

Description (number examined 63).

Length 3.4–3.6mm. Oblong-oval, convex, widest behind middle, elytron somewhat elongate posteriorly, tip sharp. Reddish yellow, portions of elytra a bit darker, sutural lines narrowly darker and bordered with pale strip, apical portions lighter; protarsi darker almost black in some specimens. Strongly, densely, and evenly punctured throughout. Pronotum and elytron narrowly margined, elytron moderately serrate towards apex, except for short distance near tip. Apical segments of both maxillary and labial palpi weakly bifid at tips. Prothoracic process narrowly lanceolate, rounded, almost keeled in cross section, slightly narrowed between procoxae. Metacoxal lines raised, moderately separated, diverging slightly posteriorly, widening to about twice their narrowest width anteriorly. Some long setae arising from pit in centre of sternite numbers three and four. A line of long setae towards sides of elytron.

Male: Pro- and mesotarsi moderately expanded, first and second segments as long as wide, claw on protarsus thickened, strongly bent near base, abruptly narrowing to sharp point at apex, with large basal tooth. Mesotibia robust, broadly but weakly indented on inner side in middle. Seta tufts on mesotrochanters somewhat thicker than on female.

Female: Mesotarsi a little expanded, protarsi less so. Protarsus with two simple claws.

Remarks

A. jenniferae can be distinguished from all other *Antiporus* by its relatively small size, and its black protarsi. It appears closest to *A. simplex* and *A. bakewelli*. From *A. simplex* it differs by its black protarsi, elytral colour pattern which although less marked than in *A. bakewelli* is clearly present, the aedeagus having a broader tip and widening slightly in the middle compared with the more parallel-sided aedeagus in *A. simplex* and the spine at the base of the claw on the male protarsi being larger than in *A. simplex*. Based on the small numbers of specimens of both species available it appears to be a little larger. From *A. bakewelli* it differs in its black protarsi, less marked and more diffuse elytral colour pattern, the aedeagus with a broader tip, and the claw on the male protarsi being straighter in comparison with the smoothly sickle-shaped claw of *A. bakewelli*.

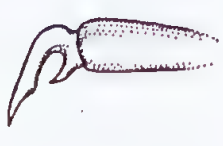
Distribution

Most specimens are from Cape York Peninsula, but it is also known from Adelaide River, N.T. (in BMNH) and Synnot Creek in northern W.A. (in ANIC).

Types

Holotype male: "25K. N. Coen Qld. 29/9/84 C. Watts" in SAMA.

Paratypes: 1, "12.40S 142°40E Qld Batavia Downs Hmsd. 17–23 Jun. 1992 T.A. Weir, at



FIGURES 16–27. **16 & 17**, dorsal and lateral view of aedeagus of *A. bakewelli*; **18**, lateral view of male *A. bakewelli* proclaw. **19 & 20**, dorsal and lateral view of aedeagus of *A. simplex*; **21**, lateral view of male *A. simplex* proclaw. **22 & 23**, dorsal and lateral view of aedeagus of *A. willyamsi*; **24**, lateral view of male *A. willyamsi* proclaw. **25 & 26**, dorsal and lateral view of aedeagus of *A. jenniferae*; **27**, lateral view of *A. jenniferae* proclaw.

light", in ANIC; 2, "12.40S 142.40E Batavia Downs Qld 03–10 Mar 1993 at light, I. Cunningham", in ANIC; 1, "16.31S 126.1E CALM site 25/1 Synnot Ck W.A. 17–20 June 1988 T.A. Weir", in ANIC; 11 "25k N. Coen Qld 29/9/85 C. Watts", in SAMA; 1, "24M.S. Musgrave N.Q. 20.5.72 J.C. Brooks at light", in ANIC; 1, "13.34S 142.32 E Qld, 17 km N.W. by W. of Rokeby (Vardons Lagoon) 27 Oct. 1992, T. Weir, P. Zborowski, Small pool with debris", in ANIC; 56, "Qld Mt. Molloy 2 km S. 30/3/96, C. Watts", in SAMA.

Antiporus pembertoni sp. nov.
(Figs 10, 11 & 12)

Description (number examined 1).

Length 4.6mm. Oblong oval, dark red brown – black, front of head, sides of pronotum broadly and sides of elytron narrowly but diffusely light-testaceous. Ventral surface testaceous, sides of meso and metasterna darker, apical tips of metatibiae darker. Dorsal surface rather finely punctured, stronger laterally, punctures on head a little smaller than eye facets, punctures at rear of pronotum towards sides and on adjacent areas of elytra tending to join in roughly longitudinal lines. Ventral surface much more strongly punctured, strongly rugose-punctate laterally. Pronotum narrowly but clearly margined, elytron weakly so. Prothoracic process narrow, strongly raised, sides sub-parallel, bluntly tipped. Metacoxal lines well separated, sub-parallel in posterior third and anterior quarter, diverging in between so that anteriorly about twice the distance apart as posteriorly, area between coxal lines and forward onto mesosterum depressed.

Male: Protarsi moderately expanded, protarsal claw large, slender, with well developed slender basal tooth. Mesotibia weakly indented on inner margin towards apex. Metafemur broadly expanded on inner edge at apex, some strong punctures and weak longitudinal ridging on expanded area.

Female: Unknown

Remarks

More weakly punctured than the other species in the *A. femoralis* complex, with the large punctures along the front of the pronotum distinct and more than twice the size of others on the pronotum. Characters of the male aedeagus and metafemur are diagnostic. Known only from a single specimen I collected in a small stream in cleared land near Pemberton.

Distribution

Known only from unique type from near Pemberton, S.W. Australia.

Type

Holotype male: "W. Aust. 15 km N.W. Pemberton, 17 May 1987, C. Watts" in SAMA.

Antiporus hollingsworthi sp. nov.
(Figs 1, 1a, 2, & 3)

Description (number examined 15).

Length 4.1–4.6mm. Oblong oval, convex. Dark red-brown, appendages lighter. Strongly evenly and densely punctate throughout, punctures smaller on head than elytra, punctures at rear of pronotum towards sides and on adjacent areas of elytra tending to join in linear longitudinal lines, punctures towards sides of metacoxae and sternites and on elytral epipleura very close together and tending to coalesce. Pronotum and elytra narrowly margined except for short distance at tips of elytra, lacking serration, sides of elytra before apex appear weakly and broadly flanged from some angles. Prothoracic process narrow, blunt, strongly carinate. Metacoxal lines sub-parallel in anterior and posterior third, rapidly diverging in middle.

Male: Pro- and mesotarsi moderately expanded. First and second segments wider than long. Claw on protarsus strongly bent near base, straight with parallel sides in middle, rapidly narrowing at apex basal tooth subobsolete. Mesotibia a little thickened, weakly and broadly indented on inner edge in middle. Apical ventral edge of mesofemur expanded a little. Inner ventral edge of metafemur with large, broad, triangular expansion in apical third. Parameres robust, broad, aedeagus arrow-headed with thin protuberance above tip arising from neck of arrow.

Female: Pro- and mesotarsi a little expanded; claws, meso- and metafemur and tibia simple.

Remarks

Antiporus hollingsworthi is a member of the *A. femoralis* group. It appears closest to *A. wilsoni* from the south-east of Australia which it resembles in the pronotal and elytral grooving, thickened male mesotibia and expanded metafemur.

Antiporus hollingsworthi can be separated from both *A. femoralis* and *A. interrogationis* by the lack of pronounced paler areas on the head, pronotum and elytra, although some specimens of

A. hollingsworthi do have head, pronotum and elytral patches paler than the rest of the upper surface. The tendency of the punctures on the rear edge of the pronotum and the adjacent areas on the elytra to link up and form grooves is more pronounced than in either *A. femoralis* or *A. interrogationis* and the triangular expansion on the male metafemur is more rounded than in either of these species. *A. femoralis* and *A. interrogationis* also lack the thickened and indented mesotibia present in *A. hollingsworthi*, *A. wilsoni* and to a lesser extent in *A. pembertoni*. *Antiporus hollingsworthi* is more strongly punctured than *A. pembertoni* and the males have differently shaped metafemora (Fig. 3). It differs from *A. wilsoni* by characters of the aedeagus, by the indentation on the male mesotibia being more central, and in having a triangular rather than a rounded expansion to the male metafemur. *Antiporus hollingsworthi* differs from all other *Antiporus* species (and all Australian Dytiscidae) by the apical appendage on the aedeagus.

Distribution

So far *A. hollingsworthi* is known only from Perth and Carrington, W.A. and from two unlocalised localities in the South-west. However, of all the Australian regions this is the most poorly sampled for water beetles so it is likely to be more abundant than the few known specimens indicate.

Types

Holotype male: "W. Aust. Maidavale, 27th April 1990, C. Watts", in SAMA.

Paratypes: 1 male, 7 females, same data as Holotype, in SAMA; 1 female "Perth 10/65 DE", in SAMA; 1 female "S.W.A. ?Rotnest, Edward", in SAMA; 1 male "JT201", in SAMA; 1 male, 1 female "R.P. McMillan, Carrington, 19.7.53", in WAM.

Etymology

Named after Rod Hollingsworth, a strong supporter of Natural History at the South Australian Museum.

Antiporus willyamsi sp. nov.
(Figs 22, 23, 24 & 28)

Description (number examined 4).

Length 3.4–3.6 mm. Oblong-oval. Widest behind middle. Testaceous, head, lateral quarters of pronotum, patches on elytra and appendages lighter, metafemur and tibia tend to be a little darker towards their apices, lighter patches on elytron tending to form broad longitudinal streaks. Strongly, densely and evenly punctate, punctures on discs of pronotum and head weaker, particularly on head, a few scattered much smaller punctures on disc of pronotum and elytra. Pronotum narrowly but distinctly margined, elytra less so. Prothoracic process with central keel, narrow between procoxae. Metacoxal lines raised, sub-parallel in posterior half and anterior quarter, diverging in between, about twice the distance apart anteriorly compared with posteriorly, reaching mesofemur. Some long setae arising from pits in centre of sternites three and four, and a line of long setae on dorsal surface of elytron close to side.

Male: Protarsi expanded, second segment broadest, mesotarsi strongly expanded, first and second segments largest, sub-equal. Mesofemur and mesotibia stouter than profemur and protibia. Protarsus with single claw, strongly bent, long and narrow, with well developed basal tooth and weak bulbous area in middle. Protrochanters with well marked cup-like tuft of golden setae, mesotrochanters with a much larger scallop-shaped tuft of similar setae. Metafemur stout, ventral inner apical region with scattered large punctures and about four longitudinal grooves/ridges.

Female: Protarsus with two weak claws. Mesotarsi moderately expanded, first and second segments largest, sub-equal. Mesotibia stout.

Remarks

The species is easily recognised by the spectacular development of the setae on the trochanters of the male which is unlike anything I

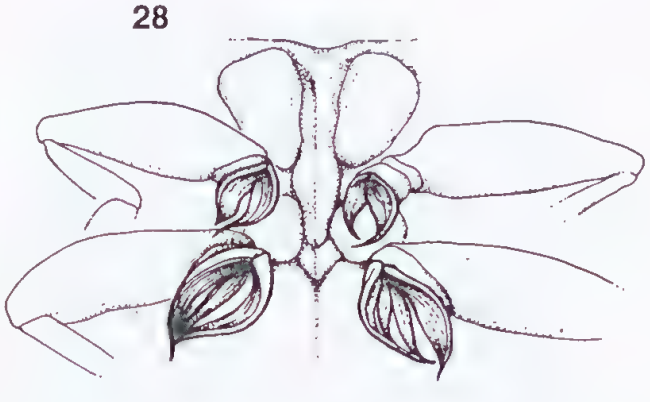


FIGURE 28. Meso- and metatrochanters of *A. willyamsi*.

have seen on other beetles. The very broad mesotarsi in the male and the striped elytral colour pattern in teneral individuals are also distinctive.

Since collecting the original specimens in 1983, I have revisited the locality (a deep, narrow, spring-fed drainage ditch in acidic soil) a number of times without success. Biologically the area has now changed considerably from a healthy habitat with numerous species to one that is almost devoid of insect life although physically little changed.

Distribution

Known only from the type locality in the south-east of South Australia and from Healesville, Victoria.

Types

Holotype male: "10 km S. Robe, S.A., 1/83, C. Watts", in SAMA.

Paratypes: 2 females, same data as holotype, in SAMA; 1 female, "Healesville, V. 12/68, C. Watts", in SAMA.

Checklist Of Australian *Antiporus* Sharp

A. bakewelli (Clark, 1862)
A. blakei (Clark, 1862)
A. femoralis (Boheman, 1858)
A. gilberti (Clark, 1862)
A. hollingsworthi sp. nov.
A. jenniferae sp. nov.
A. pembertoni sp. nov.
A. simplex Watts, 1978
A. willyamsi sp. nov.
A. wilsoni Watts, 1978
A. interrogationis (Clark, 1862)

Acknowledgments

The curators of the collections listed earlier are thanked for allowing me to examine specimens in their care. Mrs Vicki Wade typed the manuscript and Mr R. Gutteridge drew the illustrations. All these are thanked for their support and help.

References

BRANCUCCI, M. 1984. Notes on some species of the genus *Antiporus* (Coleoptera: Dytiscidae). *Aquatic Insects* 6: 149–152.

WATTS, C. H. S. 1978. A revision of the Australian Dytiscidae (Coleoptera). *Australian Journal of Zoology*, Supplementary series No 57: 1–166.

THYLACINUS MEGIRIANI, A NEW SPECIES OF THYLACINE (MARSUPIALIA: THYLACINIDAE) FROM THE ONGEVA LOCAL FAUNA OF CENTRAL AUSTRALIA

PETER F. MURRAY

MURRAY, P. F. 1997. *Thylacinus megiriani*, a new species of thylacine (Marsupialia: Thylacinidae) from the Ongeva Local Fauna of Central Australia. *Records of the South Australian Museum* **30**(1): 43–61.

Approximately 10% larger than a maximum-sized Tasmanian wolf, the late Miocene/early Pliocene *Thylacinus megiriani* n. sp. exhibits some similarities to the late Miocene thylacinid, *T. potens* Woodburne 1967 and early to mid-Miocene *Nimbacinus dicksoni* Muirhead and Archer 1990, while simultaneously expressing several derived features in common with the Recent thylacine, *T. cynocephalus*. Other than the presence of a tiny stylar cusp-like structure distal to stylar cusp D on M^3, which could be an artefact of wear, *T. megiriani* shows no definite uniquely derived characters that would exclude it from ancestry of the recently extinct *T. cynocephalus*.

Peter F. Murray, Museums and Art Galleries of the Northern Territory, PO Box 2109 Alice Springs, Northern Territory 0871, Australia. Manuscript received 14 October, 1996, revised 3 March, 1997.

Fossil vertebrates were first described from the Alcoota Local Fauna at Alcoota (Fig. 1), northeast of Alice Springs, by Woodburne (1967). The stratigraphically superposed Ongeva Local Fauna contains certain taxa that are more derived than those from the nearby Alcoota Local Fauna (Murray, Megirian & Wells 1993, Megirian, Murray & Wells 1996). Among its characteristic species is a zygomaturine diprotodontid, *Kolopsis yperus* Murray, Megirian & Wells, which is probably synonymous with the Cheltenhamian-aged *Zygomaturus gilli* Stirton 1967. *K. yperus* is more similar to *Zygomaturus* species than is the Alcoota Local Fauna species *Kolopsis torus* Woodburne 1967. *Thylacinus megiriani* appears to be analogously derived in comparison to the Alcoota Local Fauna thylacine, *T. potens*.

A direct ancestor of *T. cynocephalus* has not been identified. *T. rostralis, T. spelaeus* and *T. major* are considered to be synonymous with *T. cynocephalus* (Dawson 1982). Other thylacinids are considered to be too primitive or too specialised (Archer 1982, Muirhead & Archer 1990, Muirhead 1992, Wroe pers. com.). Ambiguity in the homology of the posterior stylar cuspules on the molars of *T. cynocephalus* has resulted in a less than definitive resolution of late Tertiary thylacinid phylogeny. *T. megiriani* provides some additional evidence pertaining to the homology of the cusps and some hypotheses of the phylogeny of the recent species of *Thylacinus* are discussed.

Materials And Methods

As is often the case with Ongeva LF fossils, NTM P9618 is not an ideal specimen, having been found in a number of pieces scattered throughout a hard nodule of calcareous sandstone. As fragments were extracted more or less individually, including fragments of the molar teeth, the specimen was glued together at the excavation site along what appeared to be the likely contacts. The fragile condition of the specimen dictated that several coats of Synocryl (Bedacryl) be applied to harden and hold it together securely. However, this compound sometimes has the disadvantage of obscuring important morphological details, particularly when fine particles of the matrix become incorporated with the solution, sometimes suppressing surface detail and occasionally even mimicking small structures.

So it was with this specimen, that certain features of the restoration seemed untenable, such as a slight overlap of the P^2 alveolus with that of the P^3. As *Thylacinus potens* has no appreciable diastema between these teeth, this arrangement appeared to be plausible, though further cleaning of the matrix and excess Synocryl from the specimen, in response to an observation by one of the referees, proved that it had not been restored correctly. This revelation provoked a more radical program of disassembly and cleaning of the specimen which I was initially afraid to attempt

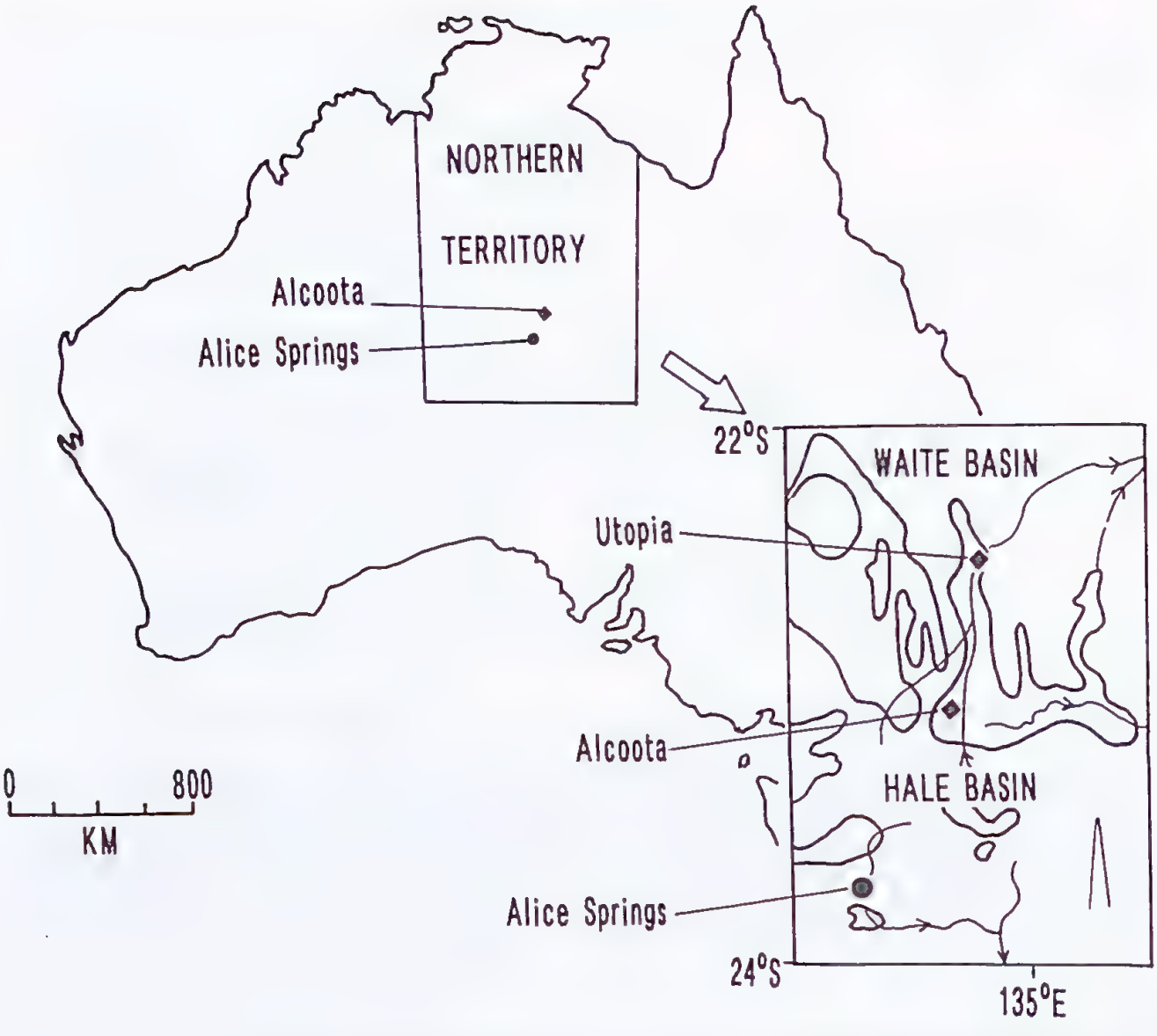


FIGURE 1. Locality map; the Ongeva LF is located on Alcoota Station, near Alice Springs Northern Territory.

due to its extreme fragility. The new restoration has greatly improved the resolution of the specimen, to the extent that many of my initial observations can be stated more confidently; though as will be discussed, some features of the specimen remain equivocal.

As the first draft of this paper was based on the original restoration, I have briefly described and illustrated the modifications I made to the specimen to avoid confusion with any errant copies of the earlier manuscript. I am extremely grateful to my referees for alerting me to the possibility that the specimen might be distorted, and for drawing to my attention several other morphological features, resulting, I believe, in a much improved account of the species.

Systematics

Family THYLACINIDAE Bonaparte 1838

Thylacinus megiriani n. sp.

Holotype

NTM P9618 (field ref. no. SQ107), left maxilla with P^1, P^3, M^{1-3}.

Type locality

Hill 1, South Quarry, approximately 2 km southwest of the junction of Ongeva and Waite Creeks, Alcoota Station, Northern Territory, latitude 22°52'S, longitude, 134°27'E. The Type

FIGURE 2. Photograph of the left maxilla of *Thylacinus megiriani* n. sp. (NTM P9618); **A**, lateral aspect; **B**, palatal aspect. This photograph depicts the field restoration of the specimen in which the fragment containing P^1 and P^2 had been glued approximately 8.0 mm posterior to its correct position, leading to the initial impression that the posterior root of P^2 was adjacent to, or slightly overlapped that of P^3. Note also that the M^3 is twisted medially (B) and is nearly a centimetre out of alignment with M^2.

was recovered from a sandy siltstone channel deposit in the Waite Formation, approximately 10m above the fossiliferous lacustrine sediments containing the Alcoota Local Fauna (Murray, Megirian & Wells 1993, Megirian, Murray & Wells 1996), (Fig. 1).

Fauna

Ongeva Local Fauna (Murray *et al.* 1993).

Rock unit and age

Waite Formation, Cheltenhamian equivalent, late Miocene-?early Pliocene.

Specific diagnosis

A large, long-snouted thylacinid, equal to, or larger than *T. cynocephalus* but less massive than *T. potens*; much larger than *N. dicksoni* (Muirhead and Archer 1990) and *T. macknessi* (Muirhead 1992). P^{1-2} shorter and narrower than in *T. potens*; P^1 in line with P^{2-3}, contrasting with *T. potens* in which P^1 is obliquely oriented and situated medial to the midline of the canine alveolus. P^3 large as in *T. potens*. Premolar diastemata longer than in *T. potens* and in *Nimbacinus dicksoni*, more comparable to *T. cynocephalus*. M^{1-3} longer and narrower than in

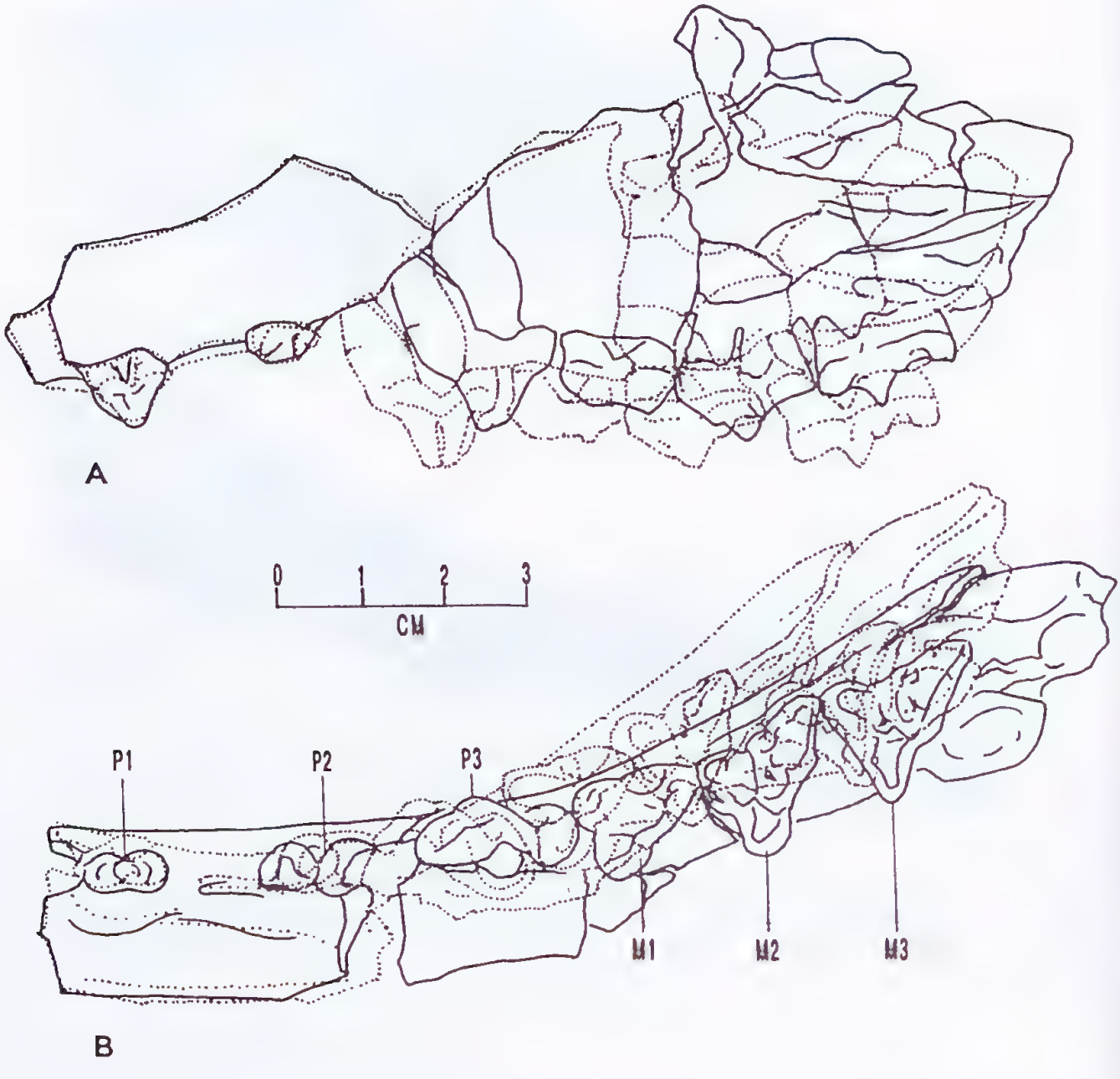


FIGURE 3. Outlines depicting changes made to the initial restoration of the specimen; solid outline represents the new restoration; compare with Fig. 2. **A**, lateral aspect; **B**, palatal aspect. The specimen was taken apart at its primary joins, cleaned of excess Synocryl and glue, and reassembled. The anterior fragment of the rostrum was carefully cleaned revealing a labial expansion representing the anterior alveolus of P^3. It was glued in place at what is probably the minimum distance from P^3, as no definite contact could be identified. Removal of additional matrix from a fragment of palate that previously did not seem to fit anywhere on the specimen, revealed the inner lining of the anterior P^3 root and was glued in position. The M^3 was twisted out of alignment with the molar row by about 15°. This region of the specimen, which consisted primarily of impacted matrix and bone fragments was embedded in modelling clay, then softened in acetone and pushed gradually back into its correct position. The area above and internal to the M^3 was then reinforced with dental plaster. These changes resulted in a significant transformation of the occlusal outline of the specimen, which subsequently lost some of its resemblances to *T. potens*.

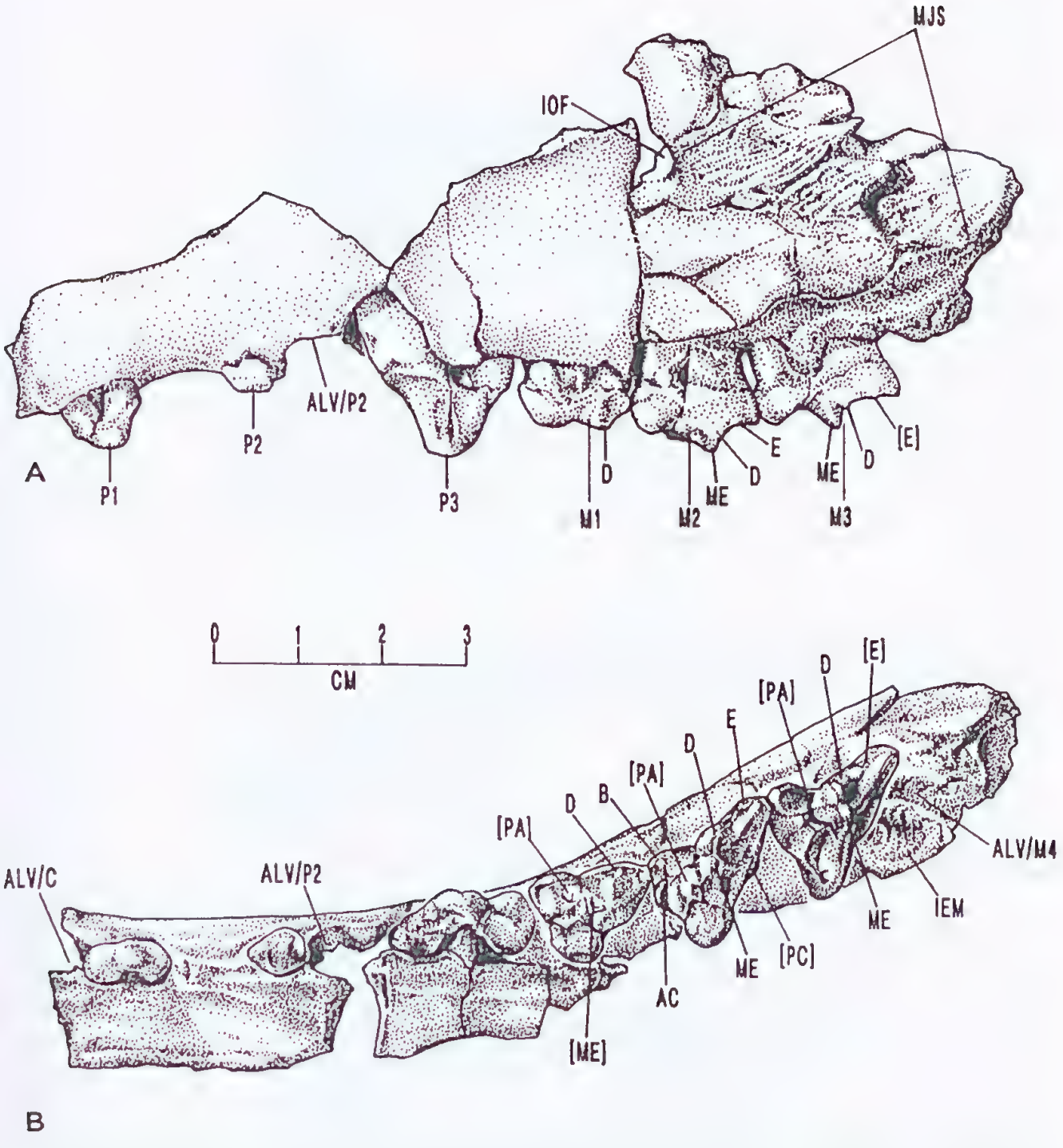


FIGURE 4. Drawing of corrected restoration of *T. megiriani* n. sp. (NTM P9618) left maxilla; **A**, lateral aspect; **B**, palatal aspect. Abbreviations: AC, precingulum; ALV/, alveolus; B, stylar cusp B; C, canine; D, stylar cusp D; E, stylar cusp E (brackets [E] indicate doubtful, or if worn, the approximate position of a structure); IEM, interdental embrasure; IOF, infraorbital foramen; M1...3, molars; ME, metacone; MJS, maxillojugal suture; P1...3, premolars; PA, paracone; PC, postcingulum.

T. potens though relatively shorter in proportion to their width than in *T. cynocephalus*. Agrees meristically with *T. cynocephalus* in that M^3 is slightly longer than M^2, differing from *T. potens* and *Nimbacinus dicksoni* in which M^2 is slightly longer than M^3. Length of molars exceeds anterior width from protocone to parastyle; stylar shelf considerably narrower than in *T. potens*; metastylar spur much larger than parastylar corner on M^3, contrasting with *T. potens* in which they are more nearly equal-sized; stylar cusp D present on M^{1-3} as in *Nimbacinus dicksoni* and probably as in *T. potens*; rudimentary stylar cusp E present on M^2, absent in *T. potens* and in *T. cynocephalus*

but present on M^{1-2} in *Nimbacinus dicksoni*. Rudimentary anterior cingulum present on M^2 in contrast to *Nimbacinus dicksoni* in which it is well-developed on M^{1-3}, *T. potens* in which it is present on M^{2-3} and *T. macknessi* in which it is present on M^1, the only upper molar known for that species. A small precingulum is present on M^2 of *T. megiriani*. Ectoflex of M^{2-3} less pronounced than in *T. potens* but greater than in *T. cynocephalus*. Paraconal reduction on M^{1-3} comparable to that of *T. cynocephalus*; protocones on M^{2-3} reduced, similar to *T. cynocephalus*. Infraorbital foramen opens above posterior half of M^2 as in *T. cynocephalus*, unlike *T. potens* in which it opens above M^1; maxillojugal suture nearly reaches the margin of infraorbital foramen, approaching the condition in *T. cynocephalus* and in contrast with *Nimbacinus dicksoni* in which it terminates considerably short of the margin of the foramen.

Etymology

It is my privilege to name this species after Dirk Megirian, Geologist, Museums and Art Galleries of the Northern Territory, Darwin, NT; who discovered and meticulously extracted the specimen.

Description

Maxilla

Thylacinus megiriani n. sp. consists of a maxilla that was recovered from nodular calcareous sandstone matrix in about a dozen pieces (Figs 2–4, 7). All but a few small fragments have been assembled into the left side of the animal's snout which includes the base of the zygomatic arch to just below the orbit and the infraorbital foramen and canal, to the posterior margin of the canine alveolus. The full extent of the missing jugal is clearly inscribed by its suture. In palatal aspect the maxilla is shallowly concave on the labial side and the snout was constricted behind P^1 much as in *T. cynocephalus*. The base of the zygomatic arch is convex and marked by a pair of low, irregular crests. The higher one, corresponding to the maxillojugal suture, extends obliquely upwards to immediately behind the opening of the infraorbital foramen.

The infraorbital foramen is a large, approximately 9.0 mm by 10.5 mm opening situated 21.0 mm above the approximate middle of the posterior half of M^2 (Figs 4, 7). Its position in *T. megiriani* is similar to that of *T. cynocephalus* and differs from the more anteriorly situated opening in *T. potens*, above M^1. Anterior to the infraorbital foramen, a shallow, oval fossa extends to above P^3, anterior to which, the lateral margin of the rostrum becomes convex.

A fragment of the maxillary palate extending from P^1 to P^2 is broken at the median suture. A prominent median palatal ridge is apparent, parallel to which runs a deep, 5.0 mm wide palatal groove. The palatal width at between the posterior roots of P^1 would have been about 24.0 mm, approximately 5.0 mm wider than in *T. potens*. The palate is narrower at this point in *T. potens* because the posterior roots of P^1 are angled inwards and are also larger, whereas they are aligned with the median base of the canine anteriorly and the P^2 posteriorly in *T. megiriani* and *T. cynocephalus* (Figs 2–5).

Three additional fragments of the palate can be approximated to adjacent structures medial to P^3–M^1 (Figs 3, 4) as additional removal of matrix and Synocryl revealed the inner margin of the P^3 alveolus on the largest of the fragments. The premolar diastemata are similar to those of *T. potens* in that the P^1 and the P^2 are widely separated, whereas the diastema between P^2 and P^3 is shorter (Figs 5, 6). In the original restoration of *T. megiriani* (Figs 2, 3) it appeared that the posterior root of P^2 might have overlapped the labial side of the anterior root of P^3 by about 3.0 mm. The specimen is broken at this point and the contacts were not quite congruent, causing the anterior part of the snout to twist out of alignment. This contact was taken apart and cleaned, revealing more of the P^2 alveolus and a straight section of diastema, indicating that a P^2/P^3 diastema of at least 5.0 mm is actually present (Fig. 6). The premolars of *T. megiriani* are large and posteriorly directed, though in proportion to the molars, the first and second premolar crowns and their alveoli are absolutely and relatively smaller than those of *T. potens* (Figs 2–6, Table 1) but the P^3 crown, though not the alveolus, is similar in size to that of *T. potens*. The lengths of the premolar alveoli of *T. megiriani* are as follows: P^1, 10.5 mm; P^2, 15.0 mm; P^3, 18.5 mm. Corresponding measurements of *T. potens* are: P^1, ~15 mm; P^2, 17.5 mm; P^3, 20.5 mm (Fig. 6).

Reconstruction

The reconstructed snout of *T. megiriani* is compared with that of *T. potens* and *T. cynocephalus* in Fig. 5. This reconstruction, based on modifications of the original restoration of the specimen (Fig. 3) indicates that although it is comparable in size and robustness to *T. potens*, its shape is more similar to that of *T. cynocephalus*

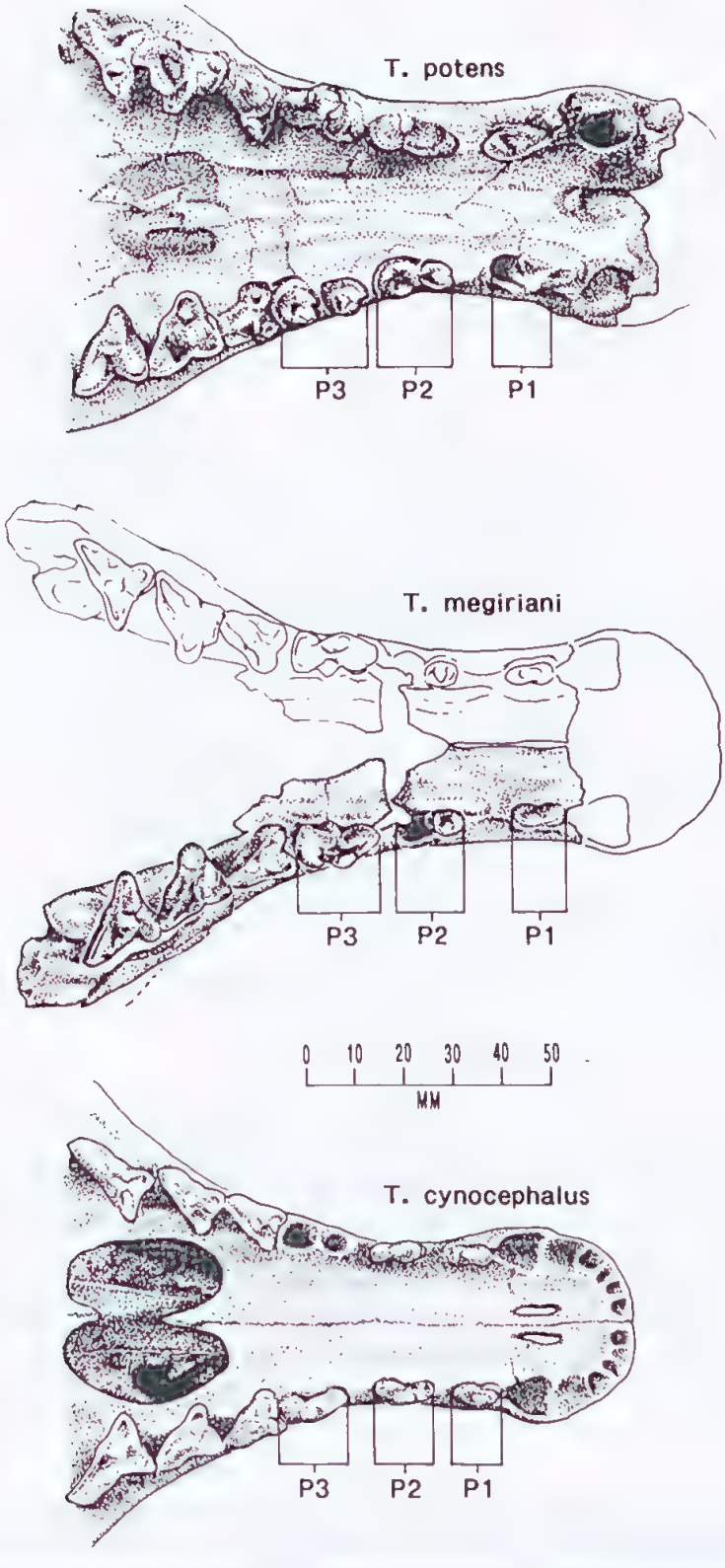


FIGURE 5. Reconstruction of the rostrum of *T. megiriani* n. sp. for comparison with those of *T. potens* and *T. cynocephalus*, drawn to scale. Comparative lengths of the premolar alveoli are indicated by brackets. *T. megiriani* n. sp. is approximately the same size as *T. potens*, both species being considerably larger and more robust than the Recent Tasmanian Wolf, *Thylacinus cynocephalus*. *T. megiriani* differs from *T. potens* in having a wider, less constricted palate at the level of P^1, in its alignment of the premolars, and in having smaller P^{1-2} alveoli and longer P^3 diastemata, all features shared with *T. cynocephalus*. Distinctive features of the rostrum and palate of *T. potens* include the large size and oblique emplacement of P^1, distinct narrowing of palate at the level of P^2, separate rather than confluent P^1 and canine alveoli, emplacement of the P^1 internal to the canine base, the incisive foramina are formed within a deep, oval pit, (apparently absent in *T. megiriani*) and the palatal fenestrae are small.

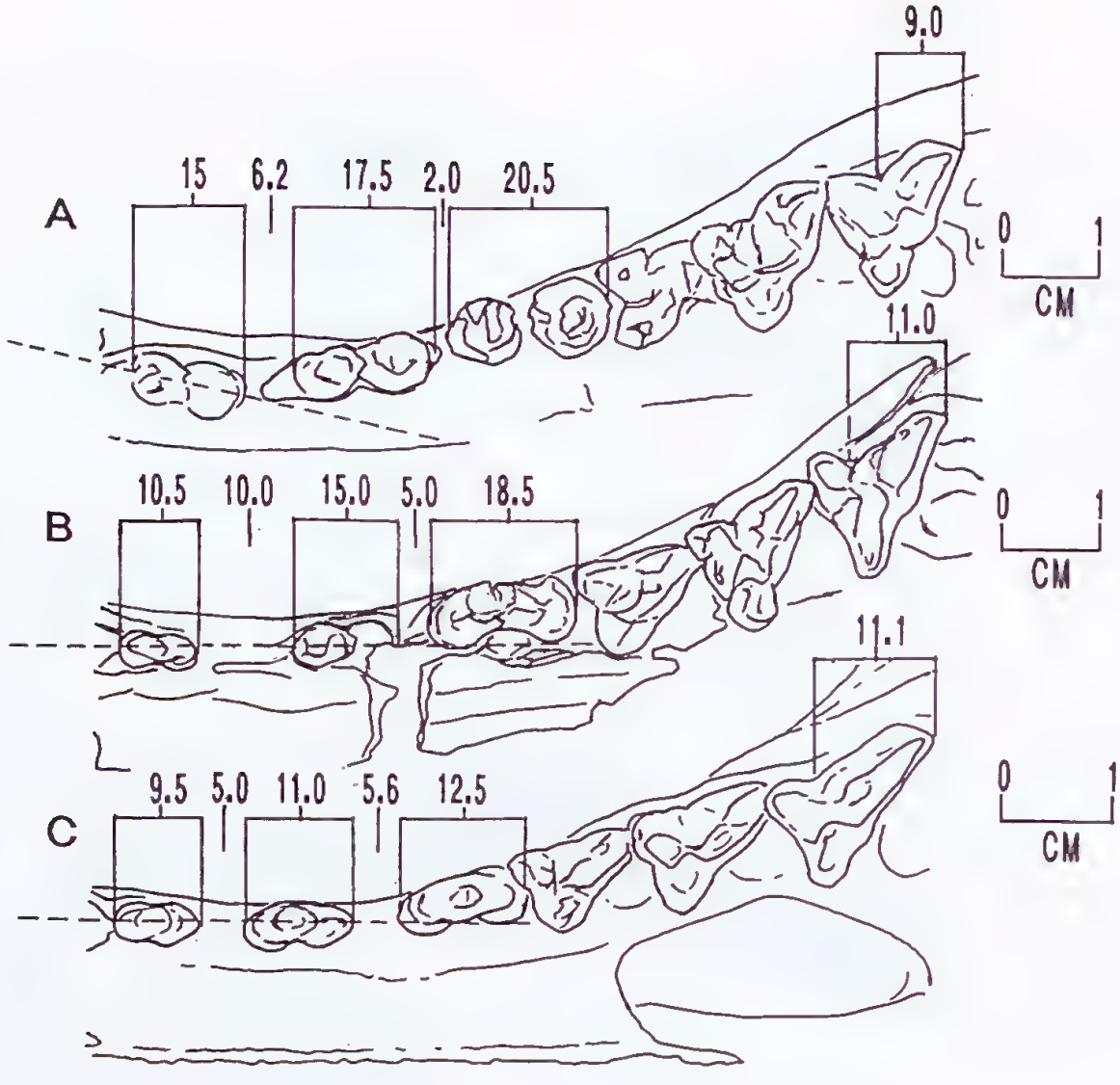


FIGURE 6. Diagram comparing proportional features of the cheek tooth rows of A, *Thylacinus potens*, B, *T. megiriani* n. sp. and C, *Thylacinus cynocephalus*, all drawn to the same length from anterior P^1 to the metastylar tip of M^3, measurements in millimetres. Refer to scale and actual measurements given above, as brackets show relative rather than scaled dimensions of the alveoli and the length of the metastylar spur from ectoflexus to tip. The P^3 alveolus in *T. potens*, damaged on both sides, is a composite restoration; note the relatively and absolutely longer diastema between P^1 and P^2 in *T. megiriani*, suggesting that the P^2/P^3 diastema was probably slightly longer than restored. The two pieces were glued at this point because no additional surface was available to provide a secure union. Observe that the diastemata in *T. cynocephalus* are approximately equal lengths.

in being more drawn out in the premolar region and in the premolar rows lying essentially parallel to each other, rather than converging at the level of P^2. As the restored P^2/P^3 diastema is a minimum dimension, the snout of *T. megiriani* may actually have been slightly longer than depicted. The distinctive median pit for the incisive foramina in *T. potens* appears to have been absent in *T. megiriani*. Note also that the P^1 alveolus is confluent with the canine alveolus in *T. cynocephalus* and *T. megiriani*, whereas in *T. potens* they are separated by a bony ridge. Longitudinal palatal crests define the lateral margins of the palatine fenestrae in *T. potens*. Similar crests in *T. megiriani* are situated further apart, indicating that the palatal fenestrae were probably wider.

Premolars

P^1 is a small two-rooted premolar closely resembling that of *T. cynocephalus*. The crown is 8.5 mm long and 4.5 mm wide. The anterior

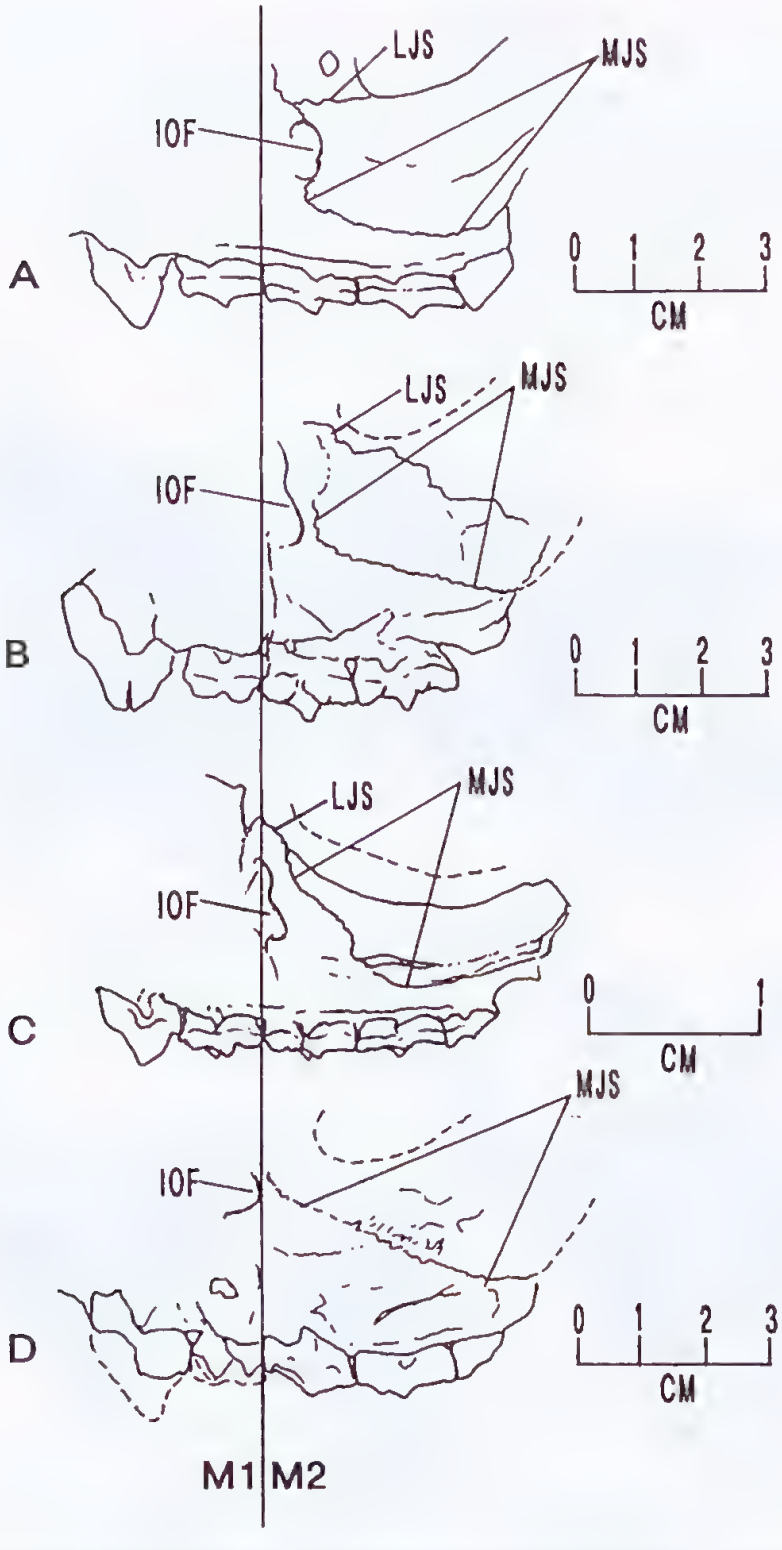


FIGURE 7. Diagram comparing the position of the infraorbital foramen relative to interproximal M^1/M^2 and its relationship to the maxillojugal suture in **A**, *Thylacinus cynocephalus;* **B**, *Thylacinus megiriani* n. sp.; **C**, *Nimbacinus dicksoni* (NTM P907–3) and **D**, *Thylacinus potens.* In this series, the infraorbital foramen in *Thylacinus potens* is positioned more anteriorly than in the other species under consideration. A more anteriorly situated infraorbital foramen is a primitive feature in didelphoids, dasyurids and probably thylacinids. However, the infraorbital foramen in *Nimbacinus* is situated more posteriorly than in *T. potens*, an otherwise much more derived species. Note that the maxillojugal suture lies well posterior to the foramen in *Nimbacinus,* whereas it reaches or nearly reaches the posterior margin of the foramen in *T. potens,* as it does in *T. megiriani* and *T. cynocephalus*. This relationship is a derived feature, suggesting that the forward position of the foramen in *T. potens* is a secondary, rather than a primary condition, indicative of a derived state. Abbreviations: IOF, infraorbital foramen; LJS, lacrimojugal suture; MJS, maxillojugal suture.

margin of the crown commences with an enamel bulge about 3.0 mm above the alveolus. The posterior profile is steeper, longer and slightly concave, terminating in an enamel thickening 1.0 mm above the alveolus (Figs 2–4, Table 1)

P^2 is represented by its anterior root and posterior alveolus. Its alveolus is about 15.0 mm long, 2.5 mm shorter than that of *T. potens*. The posterior alveolus is slightly larger in diameter than the anterior one.

P^3 is considerably the largest premolar. The length of the crown at the base of the enamel is about 16.5 mm. The circular, heavily worn posterobasal cuspule is 8.5 mm transversely,

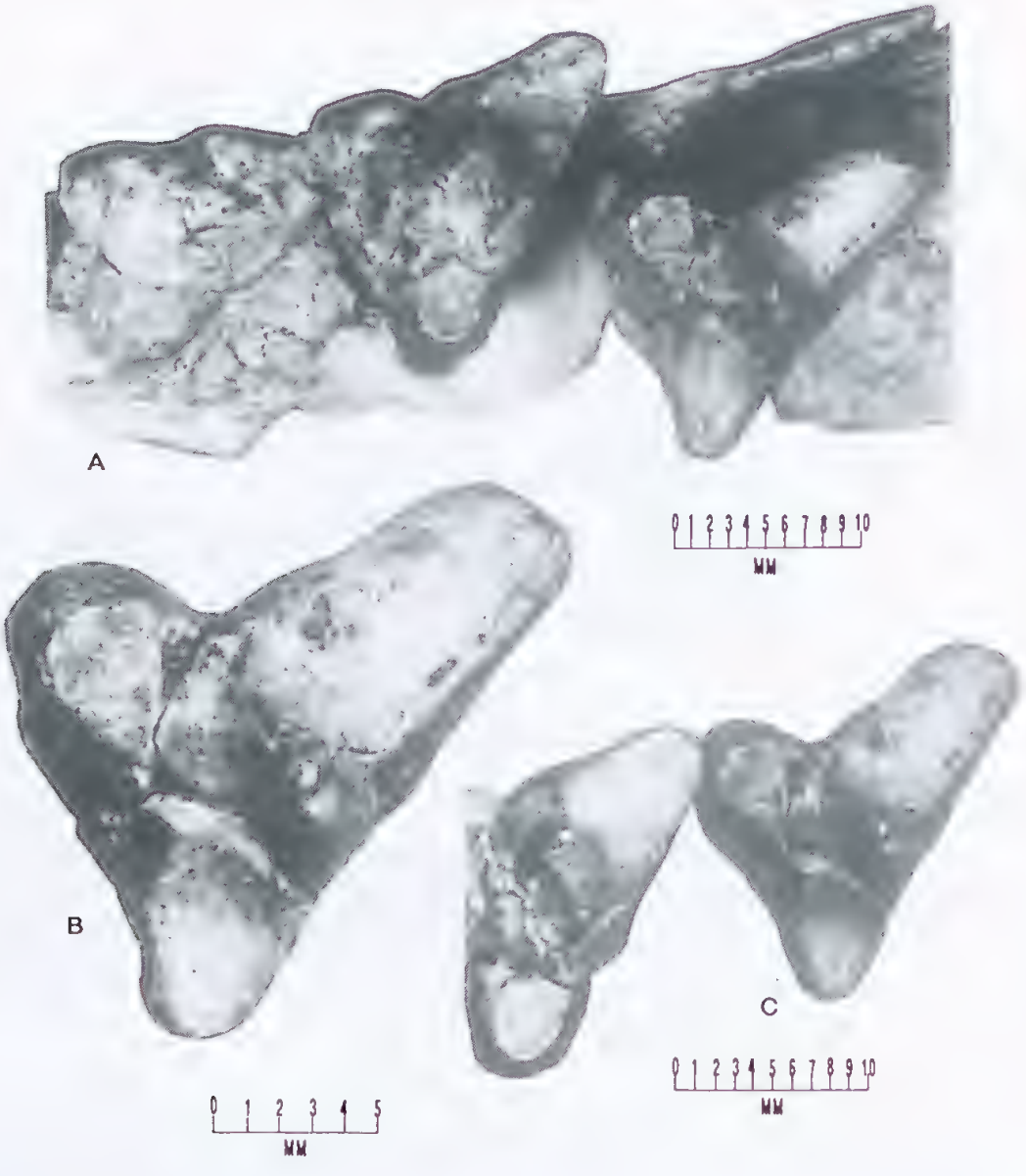


FIGURE 8. Photographs of the left M^{1-3} of *Thylacinus megiriani* n. sp.; A, M^{1-3}, taken before correction of the position of M^3 on the specimen; B, enlargement of M^3 showing stylar cusp D and possible aberrant stylar cusp E, which may actually be a peculiar wear artefact; C, paste-up showing the approximately correct alignment of the M^2 metastyle with the parastylar corner of M^3. Because of its dislocation, the occlusal surface of M^3 is tilted more lingually than those of M^{1-2}, revealing the entire buccal side of the crown and resulting in the misleading impression that the metacone is situated more posterolingually than it actually is. Note the faint, postcingulum-like structure on M^1, the small precingulum on M^2 and absence of same on M^3; The remnant stylar cusp E on M^2 is indistinct in A, but is faintly visible in C.

while the width across the anterior enamelled part of the crown immediately above the posterobasal cuspule is 7.0 mm. The crown is heavily worn on the anterior and posterior surfaces where distinct wear facets result in a steep, slightly biconcave profile.

Molars.

M^1 is heavily worn (Figs 2, 4, 8A, 9C). Both the paracone and metacone have been ground flush with the stylar shelf. The remnant base of the paracone indicates that it was probably reduced relative to the metacone. A remnant V-shaped 'wall' of vertical facets above the premetacrista and centrocrista are faintly visible on the specimen. Stylar cusp D, situated immediately posterior to the labial cleft, is the highest relief on the worn occlusal surface. Stylar cusp E is not apparent. The protocone is round and slightly constricted near its base. A faint cingulum-like crest extends from a low bulge located about mid-way between the base of the protocone and the metastylar tip, though its exact form and extent is obscured by a layer of calcite. The length of the tooth along the stylar crest is 14.7 mm. Its transverse width from the protocone to the parastyle is 12.3 mm and its posterior width from protocone to metastyle is 16.0 mm. The M^1 of *T. megiriani* is similar, but relatively longer than the equivalent tooth in *T. potens* (Fig. 9B) differing from that of *N. dicksoni* (Muirhead & Archer 1990) in its reduced stylar shelf, reduced paracone and absence of an anterior cingulum (Fig. 9A) and from that of *T. macknessi* (Muirhead 1992) in its retention of a distinct stylar shelf remnant with a large stylar cusp D, in the reduction of the paracone, in the absence of an anterior cingulum, and in having a steep facet or 'wall' above the paracone and metacone bases (Fig. 9D).

M^2 is considerably larger than M^1 and broader transversely, though slightly shorter across the stylar wings than M^3 (Figs 2, 4, 8A, C, 9C; Table 1). Its length from parastyle to metastyle is 16.8 mm. Its anterior transverse dimension from protocone to parastyle is 15.0 mm and its posterior transverse dimension from protocone to metastyle is 19.5 mm. The parastylar corner is small compared to the metastylar corner. The smaller, lower and narrower paracone is cleanly divided from the metacone by a mesial continuation of the labial cleft. Approximately 3.0 mm distal to the labial cleft and 2.0 mm labiad of the metacone is a prominent stylar cusp D. It is connected to the metacone by a short crest. Separated by a shallow labial groove from stylar cusp D is a second, much smaller enamel expansion situated about 3.0 mm anterior the metastyle, which appears to represent a remnant stylar cusp E. Although not prominent, the tiny cusp has a small wear facet and a labial bulge on the stylar shelf is evident. The anterolingual surface between the protocone and parastyle is distinctly convex and emarginated by a short, though strong precingulum. The protocone is smaller than on M^1 and is more U-shaped than rounded. Remnants of the pre-and post-protocristae extend from either side of the apex of the protocone to the bases of the paracone and metacone respectively. A small, but distinct lobe is situated immediately above the dentine-enamel junction, approximately midway between the metastyle and the protocone. In overall shape, the M^2 of *T. megiriani* is structurally intermediate between *Nimbacinus dicksoni* and *T. potens,* but differs from both in having a much reduced parastylar wing, reduced paracone and relatively reduced height of the stylar shelf. There is no indication of stylar cusp E on *T. potens,* but the cusp is well-developed, though small, in *Nimbacinus dicksoni.*

M^3 is slightly longer and more slender across the metastyle and protocone than M^2. The anterolingual and posterolingual emarginations are reduced and the precingulum is rudimentary (Figs 2, 4, 8B, C, 9C; Table 1). The parastylar spur is smaller in proportion to its metastylar component than in the previous molar, though the ectoflex is more pronounced on M^3 than on M^2. The length of the crown from parastyle to metastyle is 17.4 mm. Its anterior transverse dimension is 16.1 mm and its posterior transverse dimension is 20.3 mm. Though heavily worn, it is apparent that the paracone was originally low, narrow and much smaller than the metacone, which in turn, is high, transversely elongated and anteroposteriorly narrow. As in *Thylacinus cynocephalus*, the preparacrista is short and the internal angle formed by the preparacrista and postmetacrista is more obtuse than in *T. potens.* Prominent pre- and postprotocristae meet at the apex of the narrow, V-shaped protocone. Both crests extend to near the cusps of the paracone and metacone accentuating a furrow-like occlusal fossa between them. Stylar cusp D is situated ~3.0 mm posterior to the labial cleft in the same position relative to the posterolabial base of the metacone as in M^2. It is connected to the metacone by a low crest. A possible rudiment of stylar cusp E is situated about 4.0 mm anterior to the metastyle. Though small, it is more obvious than

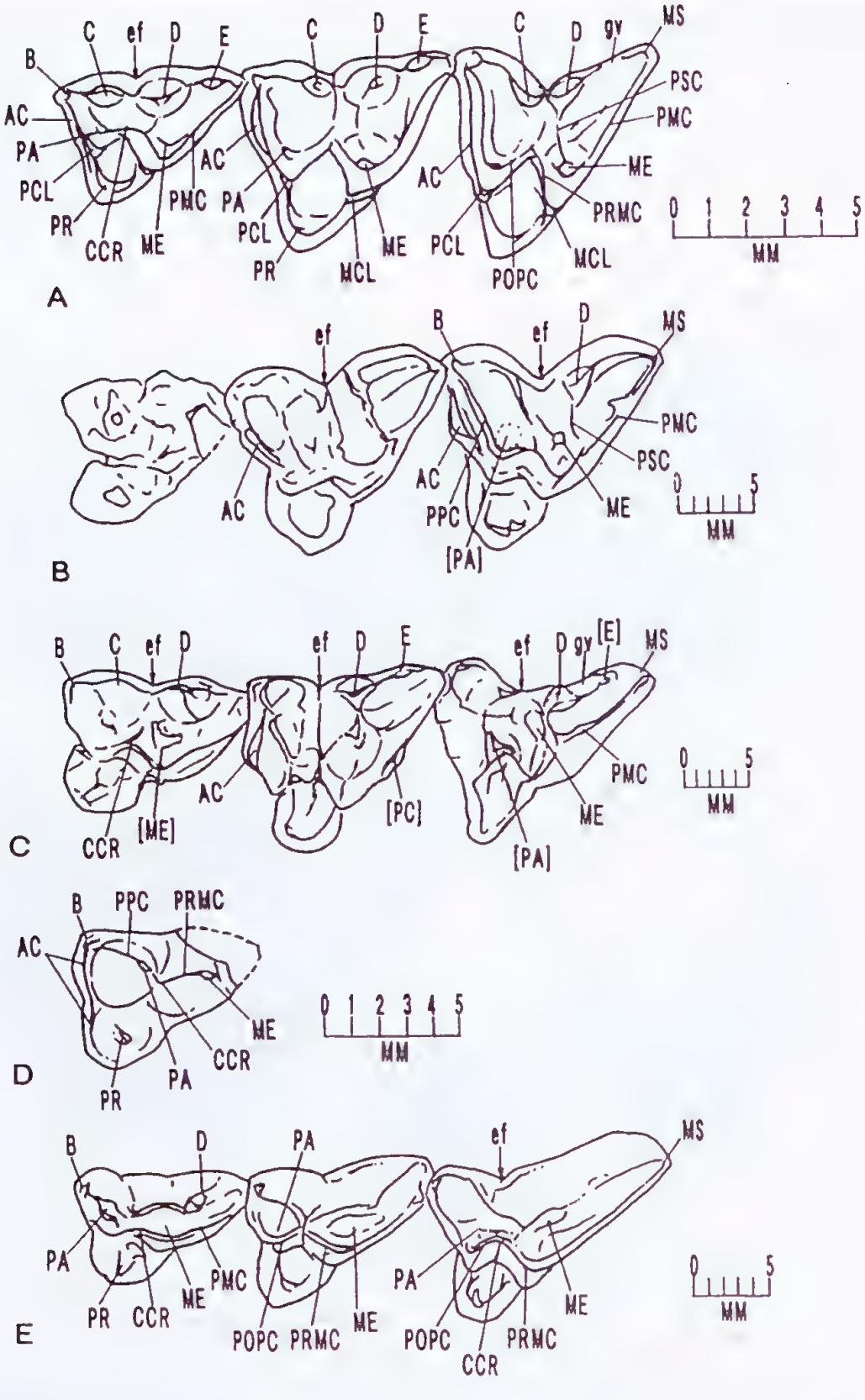


FIGURE 9. Comparison of M^{1-3} of *T. megiriani* n. sp. with thylacinid species: **A**, *Nimbacinus dicksoni* (NTM P907–3); **B**, *Thylacinus potens*; **C**, *Thylacinus megiriani;* **D**, *Thylacinus macknessi* (M^1 reversed for comparison); **E**, *Thylacinus cynocephalus*. Abbreviations: AC, precingulum; B, stylar cusp B; C, stylar cusp C; CCR, centrocrista; D, stylar cusp D; E, stylar cusp E; ef, ectoflexus; gv, natural or wear groove in stylar shelf; MCL, metaconule; ME, metacone; MS, tip of metastyle; PA, paracone; PC, postcingulum; PCL, paraconule; PMC, postmetacrista; POPC, postparacrista; PR, protocone; PRMC, premetacrista; PSC, crest connecting metacone and stylar cusp D.

TABLE 1. Measurements of cheek teeth of *Thylacinus megiriani* compared with those of *T. potens* and *T. cynocephalus*.

		T. megiriani NTM P9618	*T. potens* CPC6746	*T. potens* UCMP 66971	*T. cynocephalus* sample means (Woodburne 1967)
	L	8.5	—	—	6.2
P^1	W	4.5	—	—	3.3
	L	<12.0	12.4	—	8.3
P^2	W	<5.0	5.5	—	3.8
	L	16.5	16.0	—	10.6
P^3	W	8.5	8.8	—	5.0
	L	14.7	12.0	—	10.9
M^1	W_1	12.3	12.8	—	11.5
	W_2	16.0	13.5	—	11.5
	L	16.8	15.7	—	13.2
M^2	W_1	15.0	13.9	—	10.0
	W_2	19.5	17.5	—	15.0
	L	17.4	15.2	14.6	15.1
M^3	W_1	16.1	15.9	14.7	12.0
	W_2	20.3	19.0	17.5	17.8

the structure in the equivalent position on M^2. It consists of a nearly circular raised enamel ridge with an oval wear facet or pit in the centre (Fig. 8 B, C). After long deliberation of the structure under the microscope, I have concluded that it could represent a freakish wear pattern, but that it also indicates that thicker, more obdurate enamel is located where stylar cusp E would be anticipated. The enamel on the molars of this specimen is uniformly quite thick and it may be the case that some of these small structures, including the postcingulum-like crests on M^{1-2} might be the result of an exceptionally active enamel organ. A ~3.0 mm wide attrition furrow between stylar cusp D and the equivocal cusp E extends vertically some 4.0 mm up the labial side of the stylar crest.

Meristic gradients of the molars are as follows: metastyle to parastyle length, $M^1<M^2<M^3$; ectoflex, $M^1<M^2<M^3$; Protocone base diameter, $M^1>M^2>M^3$; Paracone, $M^1>M^2>M^3$; Metacone diameter, $M^1?M^2>M^3$; Metacone height, $M^1?M^2<M^3$; Parastyle length, $M^1>M^2>M^3$; Metastyle length, $M^1<M^2<M^3$; Precingulum, M^1 nil M^2 present M^3 nil; Stylar cusp D, $M^1>M^2>M^3$; Stylar cusp E, ? M^1, weakly expressed on M^2, ? M^3; ?Postcingulum length, $M^1>M^2$ nil on M^3 .

Discussion

The similarity in size and robusticity of *T. megiriani* to *T. potens* contributed to some of the errors in the initial restoration and interpretation of the fragmentary specimen. The new restoration of the fossil indicates that *T. megiriani* was a long-snouted species, proportionally more similar to *T. cynocephalus* than to *T. potens*. The length of the diastema between P^2 and P^3 is a minimum estimation, as no definite contact between the two fragments of the snout could be identified. The posterior margin of the fragment containing P^2 shows a definite lateral expansion for the anterior root of P^3, but the actual alveolar margin and internal lining of compact bone is absent (Fig. 3). Consequently, *Thylacinus potens* appears to have undergone proportional changes in the rostrum, possibly a forward adjustment of the zygomatic root to shift the line of action of the masseter muscle more anteriorly. Apparently related to differences in the proportions of the snout is the position of the infraorbital foramen in *T. potens*. In that species the foramen is situated more anteriorly than in *Nimbacinus dicksoni*, yet the maxillojugal suture terminates close to the margin of the foramen as in *T. megiriani* and *T.*

cynocephalus (Fig. 7). In *Nimbacinus*, the maxillojugal suture terminates a considerable distance posterior to the foramen. This particular combination of characters suggests that the condition in *T. potens* is secondary, or specialised rather than primitive, having occurred in conjunction with telescoping of the base of the rostrum.

Another specialisation in *T. potens*, now apparent, is the obliquity and rather large size of the P^1 alveolus, which is part of an overall proportional shift of the cheek tooth row in relation the rostrum. In *Nimbacinus dicksoni*, the P^1 is relatively small and lies in direct line with P^2–3 as in *T. megiriani* and *T. cynocephalus* indicating that the condition is derived. However, the position of the P^3 relative to the canine in *T. potens* is like that of *Nimbacinus dicksoni* in lying medial to the canine and in being separated from the canine alveolus by a small bony crest. These latter features are probably symplesiomorphic, whereas the relationship of the P^3 to the canine alveoli in *T. megiriani* and *T. cynocephalus* is probably synapomorphic.

Comparison of the molar morphology among *T. potens*, *T. megiriani* and *Nimbacinus dicksoni* shows a similar mixture of plesiomorphic and derived character states (Fig. 9A–E). In some aspects, such as molar shape and development of the stylar shelf, *T. megiriani* resembles *Nimbacinus dicksoni* more than it does *T. potens*. In *T. potens* the stylar shelf is high and wide, yet appears to show more reduction of the stylar cusps than *T. megiriani* and certainly more reduction than in *Nimbacinus* in which the stylar cusps D and E are well-developed on M^{1-2}, though cusp E is absent on M^3. *T. potens* shows a much greater development of the ectoflex on M^{2-3} than either *T. megiriani* or *Nimbacinus dicksoni*. These appear to be derived characters of the dentition of *T. potens*, which however, also shows some plesiomorphic states relative to *T. megiriani* and *T. cynocephalus* in retaining a well-developed precingulum on M^{2-3}, in retaining large protocone bases and in the length of M^2 exceeding the length of M^3. *T. megiriani* is derived relative to *Nimbacinus dicksoni* and *T. potens* in M^3 being slightly longer than M^2, in having more slender and proportionally longer metastylar spurs, in having reduced protocones and more reduced paracones, in the loss of the precingulum on M^3 and in having a more obtuse angle between the preparacrista and the postmetacrista. These features of *T. megiriani* trend towards the more derived states found in the molars in *T. cynocephalus*. However, *T. megiriani* is plesiomorphic relative to *T. potens* in retaining a vestige of stylar cusp E on M^2 and if the structure on M^3 represents a stylar cusp, it is autapomorphic (?reversal, eg. Marshall *et al.* 1994) among all known thylacinids in that respect.

The heavily worn condition of M^1 of *Thylacinus megiriani* renders comparison with the unworn equivalent of *T. macknessi* (Muirhead 1992) somewhat less informative. *Thylacinus macknessi* possess a well-developed anterior cingulum, which is clearly absent in *T. megiriani*. In *T. macknessi* the pre-and postprotocristae do not ascend the paracone and metacone bases to form acute crests as they do in all other thylacines including the M^1 of *T. megiriani*. The stylar shelf is well-developed on the M^1 of *T. megiriani* and much reduced in *T. macknessi*. The molar is broken in a critical position in relation to the position of stylar cusp D. In *T. megiriani*, stylar cusp D is very large and lies immediately adjacent to the metacone. This suggests that the cusp may have been reduced in *T. macknessi*. This comparison agrees in all aspects with Muirhead's (1992) observations that *T. macknessi* is more derived in the development of these features than *T. cynocephalus*, yet plesiomorphic in the retention of the anterior cingulum and autapomorphic in its extension from stylar cusp B to the base of the protocone.

Stylar cusp homologies among thylacines were more ambiguous when *T. potens* was the only fossil form of any antiquity known (Archer 1982). The expression of the cusps in *Nimbacinus dicksoni* is now well-documented, and accords with other members of the family Thylacinidae (Muirhead & Archer 1990). In *Nimbacinus dicksoni*, stylar cusps B, D and E are present on M^{1-2} and stylar cusp D is present on M^3 whereas cusp E is absent from that tooth. In *T. potens*, stylar cusp D is definitely present on M^3 and almost certainly was present on M^{1+2}, though the crowns are damaged in the region that the cusps are usually situated. There is no sign of stylar cusp E on M^{2-3} in that species. In *T. megiriani*, stylar cusp D is well-developed on M^{1-3} whereas stylar cusp E is rudimentary on M^2. I am disinclined to attribute any phylogenetic significance to the cusp-like structure in the position of stylar cusp E on the M^3 of *T. megiriani*, although its putative existence is duly noted should future finds serve to either verify or negate its presence.

In *T. cynocephalus*, stylar cusps are absent on M^{2-3} in conjunction with the reduction of the stylar shelf. A small stylar cusp occupying the usual

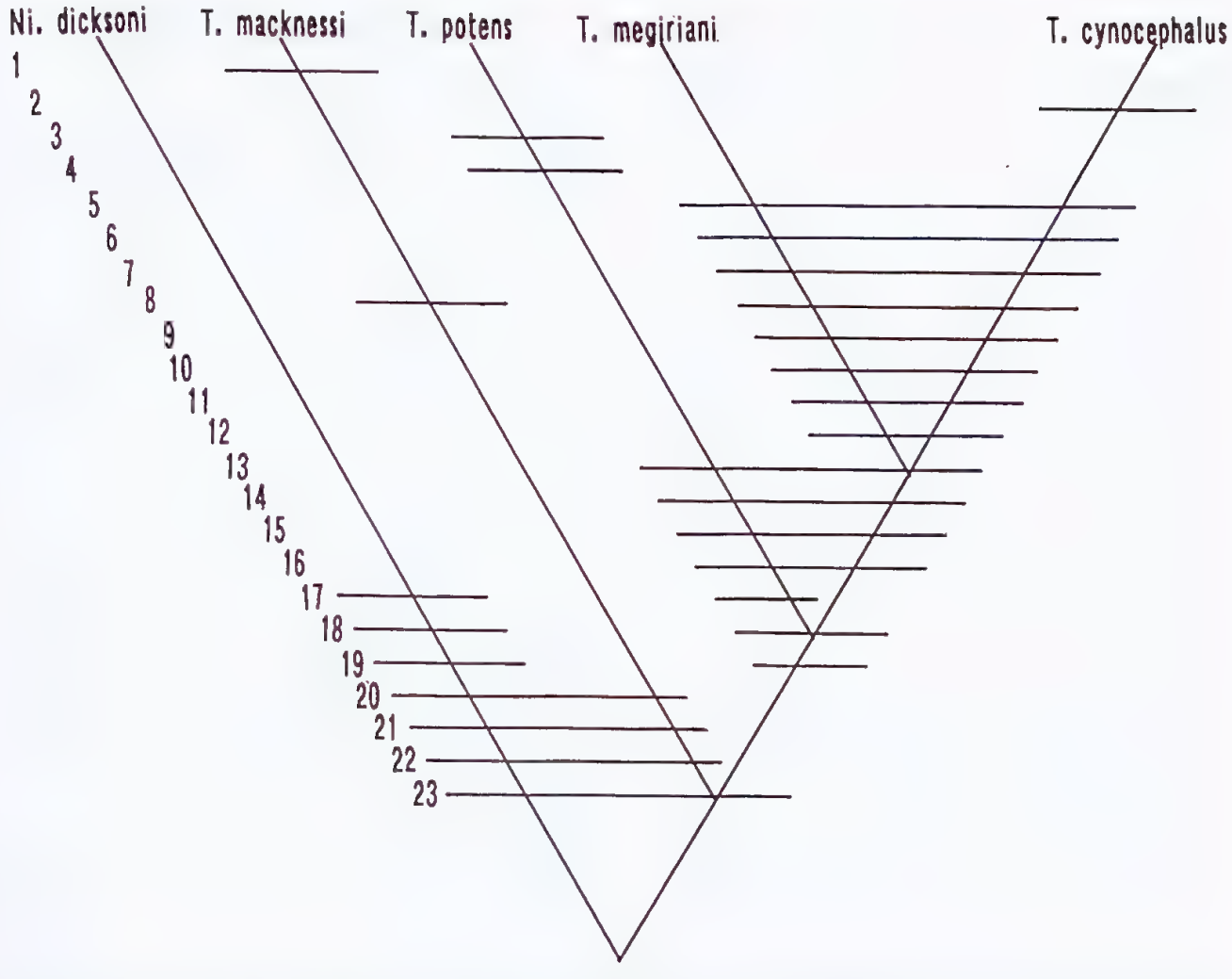


FIGURE 10. Character distribution in species of Thylacinidae. 1–16 are apomorphic, 17–23 are plesiomorphic: 1, loss of 'wall' below postparacrista and premetacrista; 2, transverse narrowing of molars and loss of stylar cusp D on M^{2-3}; 3, widened, elevated stylar crest, suppression of stylar cusp E at least on M^2; 4, increased ectoflex; 5, lengthened premolar diastemata; 6, confluent P^1–C diastema; 7, elongation of metastyle, reduced parastyle, obtuse angle between preparacrista and postmetacrista, M^3 longer than M^2; 8, reduced stylar shelf; 9, reduced protocone; 10, loss of precingulum and increased concavity of anterior margin of M^3; 11, reduced ectoflexus; 12, posterior position of infraorbital foramen above middle of M^2; 13, reduced paracone; 14, loss of precingulum on M^1; 15, forward extension of maxillojugal suture to posterior margin of infraorbital foramen; 16, large body size; 17, (plesiomorphic) absence of diastema between P^2/P^3; (plesiomorphic) notched precingulum on M^2–M^3; 19, (plesiomorphic) P^1 situated lingual to canine; 20, (plesiomorphic) retention of precingulum on M^1; (plesiomorphic) 21, large paracone; 22, (plesiomorphic) metaconid on M^3; 23 (plesiomorphic) small body size.

topological position of stylar cusp E is present on M^1. This cusp was initially identified by Archer (1982) as stylar cusp E. Subsequently, Muirhead and Archer (1990) identified the cusp as stylar cusp D that had become reduced and migrated posteriorly in conjunction with the elongation of the metastyle. The predisposition of the stylar cusps in *T. megiriani* supports the latter conclusion, in that if stylar cusp E was present, it was already extremely reduced relative to stylar cusp D. Moreover, there is no satisfactory explanation of the fate of stylar cusp D had cusp E been retained, as its amalgamation with the metacone, analogous to *Sarcophilus* (Crabb 1982) appears to have been highly unlikely (Stephen Wroe, pers. com.).

Phylogenetic position of *T. megiriani*

The character evaluations employed here are based on those of Muirhead and Archer (1990). As the new species exhibits additional structures,

the character polarities pertaining to those structures are based on the observations made in the discussion. An hypothesis of the phylogenesis of *T. megiriani* is drawn from the following postulations (Fig. 10):

Thylacinus cynocephalus–T. megiriani synapomorphies: lengthened premolar diastemata, confluent canine–P^1 alveoli, posteriorly situated infraorbital foramen (in line with middle of posterior half of M^2), elongation and narrowing of the metastyle of M^3 (including M^3 longer than M^2, reduced width of parastyle, obtuseness of angle of postmetacrista and premetacrista and reduction of height of stylar shelf), greatly reduced paracone particularly on M^{2-3}, reduction of diameter of protocone base, loss of precingulum and concave profile of anterior surface of M^3, reduction of ectoflexus on M^{2-3}.

Thylacinus potens–T. megiriani–T. cynocephalus synapomorphies: loss of precingulum on M^1, forward extension of maxillojugal suture to margin of Infraorbital foramen, possibly large size.

Thylacinus potens–Nimbacinus dicksoni symplesiomorphies: absence of diastema between P^2 and P^3, presence of precingulum on M^{2-3}, P^1 situated lingual side of canine.

Thylacinus macknessi–Nimbacinus dicksoni symplesiomorphies: retention of anterior cingulum on M^1, large (unreduced) paracone, possibly small size, remnant metaconid on M^3.

Thylacinus megiriani–Nimbacinus dicksoni symplesiomorphy: expression of stylar cusp E on M^2.

Thylacinus megiriani apomorphies: possible expression of stylar cusp E on M^3 (reversal?), possible expression of anterobasal cuspule or small postcingulum on M^{1-2} (?neomorphic).

Thylacinus potens apomorphies: extreme development of labial emargination of molars, stronger ectoflexus on M^{2-3}, forward position of infraorbital foramen, obliquity and large size of P^1, enlarged trigonid and/or reduced talonid in lowers.

Thylacinus macknessi apomorphies: extreme reduction of stylar shelf, absence of crests ascending lingual bases of paracone and metacone, postparacrista and premetacrista connect low in the crown basin consequently the lingual wall below the paracone and metacone is absent.

Thylacinus cynocephalus apomorphies: extreme elongation of metastyle on all molars, extreme reduction of stylar shelf, loss of stylar cusp D on M^{2-3}.

Probably because there are so few species and relatively few characters due to the fragmentary nature of the fossils, the resulting phylogeny seems to be fairly straight-forward (Fig. 11). Among the species considered, *Nimbacinus dicksoni* is by far the least derived form. In contrast, *T. macknessi*, while retaining more plesiomorphic features than any of the remaining species, is simultaneously more specialised than *T. cynocephalus*. It is therefore the least likely candidate for ancestry of any of the three later species (*T. potens, T. megiriani* and *T. cynocephalus*). *T. potens* is also highly derived in its extreme thickening of the labial emargination of the molars, deep ectoflex, relatively narrow talonid and possibly in some degree of rostro-facial proportional sliding. This species shows subtle modification of the relative proportions of the snout that are probably secondary because the forward extent of the maxillojugal suture relative to the infraorbital foramen appears to be synapomorphous with *T. megiriani* and *T. cynocephalus*. In several respects, *T. megiriani* is the least derived of the large species in retaining a rudimentary stylar cusp E on M^2 , in retaining large stylar cusps D on M^{1-3} and in retaining a general proportional similarity in its molars to those of *Nimbacinus dicksoni*. However, other characters of *T. megiriani* show closer resemblances to those of *T. cynocephalus* than observed in any of the other species.

In general appearance, the differences between *T. megiriani* and *T. potens* are quite subtle. Its large size and robustness, relatively small, broad molars, large P^3, presence of stylar cusp D and deep maxilla all bear a close resemblance to *T. potens*, to the extent that when I first saw the specimen in the field, I thought it might represent an extreme individual variation of the latter species. This resemblance biased my initial restoration of the specimen, although in spite of this, its detailed differences considerably outweighed the introduced and genuine similarities. It is an important feature of the specimen that while the state of many of its characters show an unambiguous trend towards *T. cynocephalus*, it is probably further removed structurally from the modern species than it is from *T. potens*. A reasonable stage of evolution estimation for the time of separation of *T. potens* and the lineal ancestor of *T. megiriani* would be in the later part of the mid-Miocene.

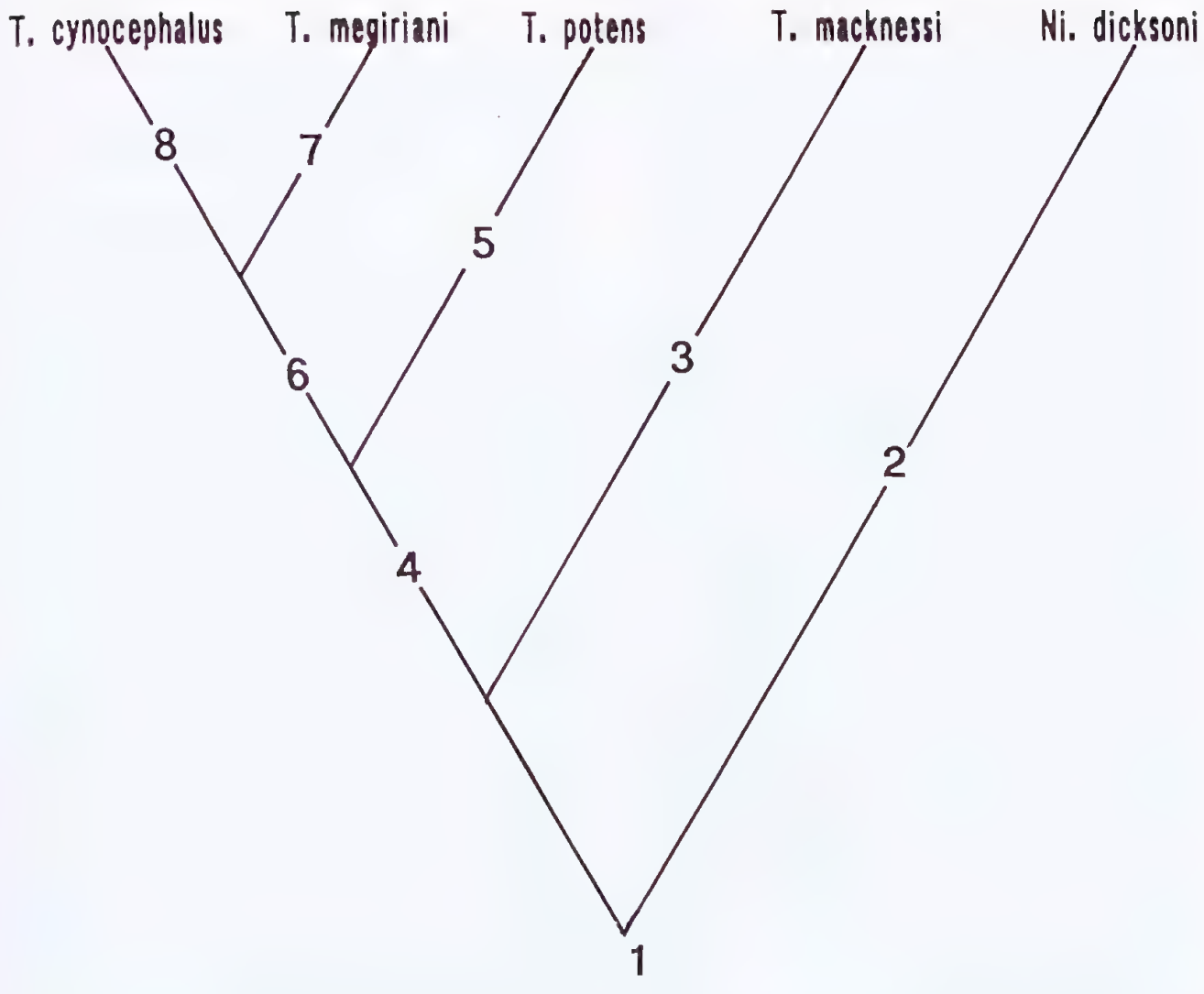


FIGURE 11. Subjective dendrogram depicting hypothesis of phylogenetic relationships among thylacinid species; 1, loss of stylar cusp E on M^3, loss of high postcingulum M^{1-3}, plesiomorphic states of large paracone and small size; 2, more posterior position of infraorbital foramen; 3, reduced stylar shelf, loss of 'wall' above postparacrista, centrocrista and premetacrista, extended precingulum M^1; 4, loss of precingulum on M^1, forward extension of maxillojugal suture to margin of infraorbital foramen, large size, reduction of stylar cusp E on ?all molars; 5, widened, elevated labial emargination of molars, increased ectoflex on M^{2-3}, loss stylar cusp E on at least M^2; 6, increased length premolar diastemata, reduced stylar shelf, reduced parastyle and paracone, lengthened metastyle, reduced ectoflex, more posteriorly situated infraorbital foramen; 7, possible neomorphic faint, low postcingulum on M^{1-2}, possible stylar cusp E on M^3; 8, increased reduction of stylar shelf, increased elongation of metastyle, stylar cusp D confined to M^1, reduced ectoflex.

Palaeobiology and biochronology

The Ongeva Local Fauna shows a distinct faunal change from the underlying Alcoota LF. A zygomaturine, close to, if not synonymous with *Zygomaturus gilli* is the dominant large herbivore, apparently replacing *Plaisiodon centralis* which it resembles somewhat in size and general morphology. A species of the crocodile *Quinkana* is relatively common, whereas the dominant Alcoota crocodilian, *Baru*, is absent. Though the sample is too small to be definitive, it would appear that *T. megiriani* had replaced the Alcoota LF thylacinid species, *T. potens* by Ongeva times. A new small ratite bird, possibly a dromornithid, is also present in the Ongeva LF (Megirian, Murray & Wells 1996).

Continuity with the Alcoota LF is indicated by the presence of *Kolopsis torus* Woodburne 1967, *Dorcopsoides sp.*, *Dromornis* sp. cf. *D. stirtoni* and *Ilbandornis sp.* The Ongeva *K. torus* appears to be little changed from the Alcoota population, suggesting a fairly short interval between the two local faunas. Because the depositional

circumstances of the two faunas differ, it is not entirely clear as to whether the samples represent distinct communities within a basically stable environment or are a reflection of more general, possibly fairly rapid changes in the biotic attributes of the region.

Thylacinus potens is a highly specialised thylacinid showing as least as much, if not more, derivation in its molar morphology from *Nimbacinus dicksoni* than *T. megiriani*. The increased width of the stylar area and relative widening of the trigonids and narrowing of the talonids of the lower molars, combined with its robust skeletal attributes, indicate that *T. potens* was capable of shearing and crushing highly resistant tissues, and may have been somewhat hyena- or *Osteoborus*-like in its habits. *T. megiriani* shows an incipient trend towards the extreme carnassialisation that distinguishes *T. cynocephalus*; consequently it may have been more actively predacious in its habits than *T. potens*. It is likely that the two species would have considerable overlap in their habitat preference and behaviour. Given their close similarities and large size, it seems improbable that they would have occurred sympatrically. Such large predatory species usually have a considerable range, and it is therefore a more plausible speculation that *T. megiriani* represents a successional replacement of *T. potens* rather than an addition to the previously existing fauna.

Conclusions

As in *T. potens*, the new species has a large P^3, retains stylar cusp D and has transversely wide molars. *T. megiriani* differs from *T. potens* in many of the features that also serve to distinguish the latter from *T. cynocephalus*. These include reduced ectoflex of M^{2-3} and stylar shelf on M^3, increase in the length relative to width of M^3, narrow protocones, reduction of P^{1-2} relative to the molars, alignment of the premolar row and infraorbital foramen opening above posterior M^2. *T. megiriani* shows no definite structural features that would preclude it from ancestry of *T. cynocephalus* and shows a number of synapomorphous features including reduced paracone and lengthened postmetacrista. *T. megiriani* is less specialised within the morphological extremes of the large size and powerful shearing/crushing dentition of *T. potens* and the small-sized, extreme shearing modifications of *T. macknessi*. The addition of this specimen to the small existing collection of fossil thylacines seems to help clarify and simplify our current understanding of the phylogeny of the group.

Thylacinus macknessi indicates that a highly derived shearing complex had evolved in the early to mid Miocene among thylacinids, but did not lead to the development of the Recent thylacine species, *T. cynocephalus*, which appears to have originated in the late Pliocene. It is likely therefore that extreme carnassialisation in the larger thylacinid species took place in the late Cainozoic, perhaps in response to the radiation of macropodine species that commenced in the early to mid Pliocene (Flannery 1989). A tempting speculation, based on the circumstantial evidence for periodic drought in Alcoota times (Murray & Megirian 1992) is that there may have been an abundance of carrion over a sufficient duration to have selected for a large mammalian scavenging species. Following subsequent climatic amelioration in the terminal Miocene, the hyena-like *T. potens* was out-competed by the more predacious *T. megiriani*. The subsequent loss of *Thylacinus potens* as a possible scavenging predator may have left the somewhat less productive scavenging niche open, recruiting a smaller species; namely, the ancestor of the living Tasmanian Devil, *Sarcophilus harrisi*.

Acknowledgments

I am indebted to Jeannette Muirhead and Alex Baynes for their useful comments on the first draft of this paper. Their observations led to the correction of a number of important details relating to the original restoration of the specimen and several key morphological features of which I was unaware were generously and courteously pointed out to me. I thank Dirk Megirian for his outstanding contribution to all aspects of the excavation, interpretation and documentation of the Alcoota/Ongeva Locality and, of course, for giving me the opportunity to describe and name this interesting species after him. I am very grateful to Ian Archibald, the NT Museum's Preparator/Taxidermist who photographed and printed the bromides under difficult circumstances. I also thank Rod Wells and the Flinders University students who participate in the Alcoota excavations annually. The field work at Alcoota is partially supported by an NT Heritage Grant.

References

ARCHER, M. 1982. Review of Miocene thylacinids (Thylacinidae, Marsupialia), the phylogenetic position of the Thylacinidae and the problem of apriorisms in character analysis. Pp 445–76 *In* 'Carnivorous Marsupials'. Ed. M. Archer. Royal Zoological Society of New South Wales: Sydney.

CRABB, P. L., 1982. Pleistocene dasyurids (Marsupialia) from southwestern NewSouth Wales. Pp. 512–16 *In* 'Carnivorous Marsupials'. Ed. M. Archer. Royal Zoological Society of New South Wales: Sydney.

DAWSON, L. 1982. Taxonomic status of fossil thylacines (*Thylacinus*, Thylacinidae, Marsupialia) from Late Quaternary deposits in eastern Australia. Pp. 527–36 *In* 'Carnivorous Marsupials'. Ed. M. Archer. Royal Zoological Society of New South Wales: Sydney.

FLANNERY, T. 1989. Phylogeny of Macropodoidea; a study in convergence. Pp. 447–506 *In* Kangaroos, Wallabies and Rat Kangaroos. Ed. G. Grigg, P. Jarman and I. Hume. Surrey Beatty and Sons and the Royal Zoological Society of New South Wales, Sydney.

MARSHALL, C., RAFF, E. & RAFF, R. 1994. Dollo's law and the death and resurrection of genes. *Proceedings of the National Academy of Science, USA*. **91**:12283–12287.

MEGIRIAN, D., MURRAY, P. & WELLS, R. 1996. The Late Miocene Ongeva Local Fauna of Central Australia. *The Beagle, Records of the Museums and Art Galleries of the Northern Territory.* **13**: 9–38.

MUIRHEAD, J. & ARCHER, M. 1990. *Nimbacinus dicksoni*, a plesiomorphic thylacine (Marsupialia:Thylacinidae) from Tertiary deposits of Queensland and the Northern Territory. *Memoirs of the Queensland Museum* **28**(1): 203–221.

MUIRHEAD, J. 1992. A specialised thylacinid, *Thylacinus macknessi,* (Marsupialia: Thylacinidae) from Miocene deposits of Riversleigh, Northwestern Queensland. *Australian Mammalogy* **15**: 67–76.

MURRAY, P. & MEGIRIAN, D. 1992. Continuity and contrast in middle and late Miocene vertebrate communities from the Northern Territory. *The Beagle, Records of the Northern Territory Museum of Arts and Sciences* **9**(1): 89–110.

MURRAY, P., MEGIRIAN, D. & WELLS, R. 1993. *Kolopsis yperus* sp. nov. (Zygomaturinae, Marsupialia) from the Ongeva Local Fauna: new evidence for the age of the Alcoota fossil beds of central Australia. *The Beagle, Records of the Northern Territory Museum of Arts and Sciences* **10**(1): 155–172.

STIRTON, R. A. 1967. New species of *Zygomaturus* and additional observations on *Meniscolophus,* Pliocene Palankarina Fauna, South Australia. *Bureau of Mineral Resources, Geology and Geophysics, Australia, Bulletin* **85**: 129–150.

WOODBURNE, M. O. 1967. The Alcoota Fauna, Central Australia: an integrated palaeontological and geological study. *Bureau of Mineral Resources, Geology and Geophysics, Australia, Bulletin* **87**: 1–187.

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A NEW SPECIES OF MULTIPHASED *CORBULIPORA* MACGILLIVRAY, 1895 (BRYOZOA: CRIBRIOMORPHA) FROM SOUTHWESTERN AUSTRALIA.

P. E. BOCK & P. L. COOK

BOCK, P. E. & COOK, P. L. 1998. A new species of multiphased *Corbulipora* MacGillivray, 1895 (Bryozoa: Cribriomorpha) from southwestern Australia. *Records of the South Australian Museum* 30(2): 63–68.

A new Recent species of the cribriomorph genus *Corbulipora*, *C. inopinata*, is described from several localities in the western part of the Great Australian Bight. All species of *Corbulipora*, both Recent and fossil, are known to occur in several phases. The form of the subcolonies, and the characters of the component zooids may be very different in each phase, and subcolonies are capable of separate existence. *C. inopinata* occurs in an encrusting phase, in a flustriform, ovicellate phase, and a bilaminar rooted phase. All zooids have some form of cribriomorph frontal shield, unlike some of those of the closely related *C. tubulifera*. The shield has, however, different characters in each phase.

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The occurrence of distinct phases of correlated colony growth form and zooid morphology in species of *Corbulipora* has been described in some detail by Bock and Cook (1994; in press). Essentially, the function of the phases appears to be the same in all species. The first, ancestrulate phase is minute, encrusts shells and shell fragments, and may even have an interstitial existence. It establishes the colony and results from the settlement and metamorphosis of a motile larva. The second, erect phase is cellularine or flustrine, and arises from stalk-like kenozooids and autozooids growing from the peripheral pore-chambers of the zooids of the primary phase. This phase develops ovicells and large interzooidal avicularia. The second phase gives rise in various ways to a small, bilaminar or frontally budded third phase, which is known, in Recent species, to be anchored by numerous rhizoids. As the ovicelled second phase tends to be thinly calcified, the delicate subcolonies may easily be destroyed, or at least detached from their origins. The bilaminar phase maintains the position of the colony and develops further ovicellate subcolonies, which may be able to alternate with it more than once (Bock & Cook in press).

Collections of bryozoans, made by the R.V. Franklin, using an epibenthic sled, from localities in the western Great Australian Bight in July 1995, have produced a wealth of specimens and species. These include subcolonies of *C. tubulifera* and of an undescribed species of *Corbulipora*, which has several distinctive features.

Materials And Methods

Specimens are stored in the Collections of the Museum of Victoria (MOV) and South Australian Museum (SAM). Specimens for scanning electron microscopy were coated with gold.

The Stations from which specimens of *Corbulipora* were obtained were as follows:

C. inopinata sp. nov.

GAB 118 34°59'S, 119°00'E, 85m. Young non-ancestrulate colonies encrusting worn adeonid and lunulite colonies of bryozoans.

GAB 098 34°39'S, 122°26'E, 156m. 1 phase-2 subcolony with numerous avicularia.

GAB 093 34°32'S, 122°58'E, 95m. 1 phase-1 subcolony and 1 phase-2 subcolony with ovicells.

GAB 083 34°21'S, 124°08'E, 180m. 2 phase-1 subcolonies encrusting *Turritella* shells.

GAB 049 33°53'S, 125°22'E, 156m. 4 phase-2 subcolonies, developing into phase-3 at tips, one repeating phase-2.

GAB 056 33°19'S, 125°43'E, 73m. 2 large phase-

2 subcolonies, one with ovicells, developing from phase-3 subcolonies.

GAB 045 33°25'S, 125°58'E, 143.5m. 3 small phase-3 subcolonies with stalks.

GAB 020 33°20'S, 129°18'E, 157m. 9 small phase-2 subcolonies, 2 developing from phase-3 subcolonies.

GAB 013 33°06'S, 130°00'E, 101m. 2 phase-2 subcolonies, one with ovicells, and one phase-3 with numerous rhizoids and one phase-2 subcolony.

GAB 014 33°16'S, 130°00'E, 155m. 2 phase- 3 subcolonies developing into phase-2 subcolonies, plus 5 isolated stalks.

C. tubulifera (Hincks)

GAB 019 33°22'S, 129°19'E, 301m. 7 phase-2 subcolonies, and 2 phase-3 subcolonies.

Systematics

Order Cheilostomatida Busk, 1852

Superfamily Cribrilinoidea Hincks, 1879

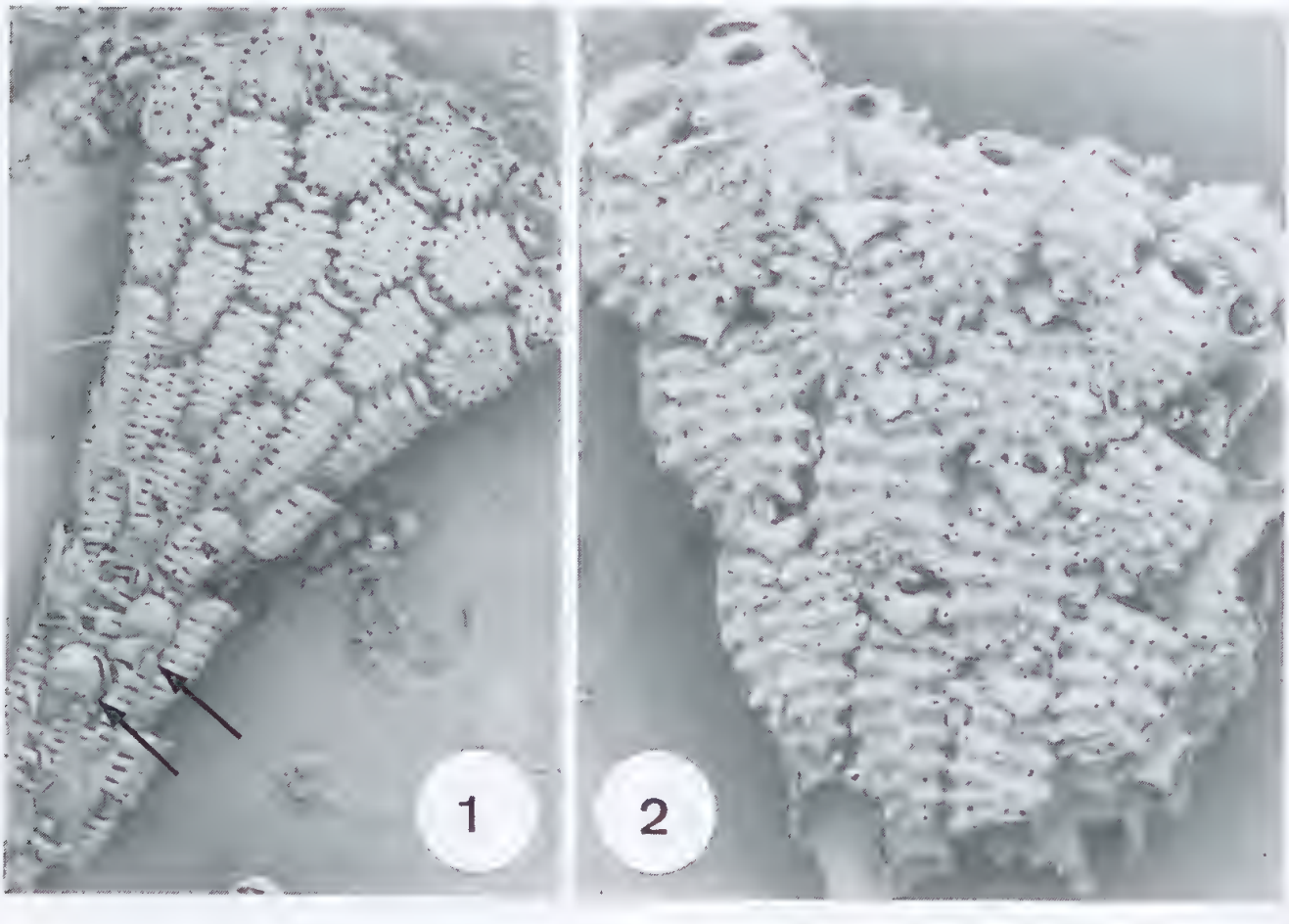
Family Cribrilinidae Hincks, 1879

Genus ***Corbulipora*** MacGillivray, 1895

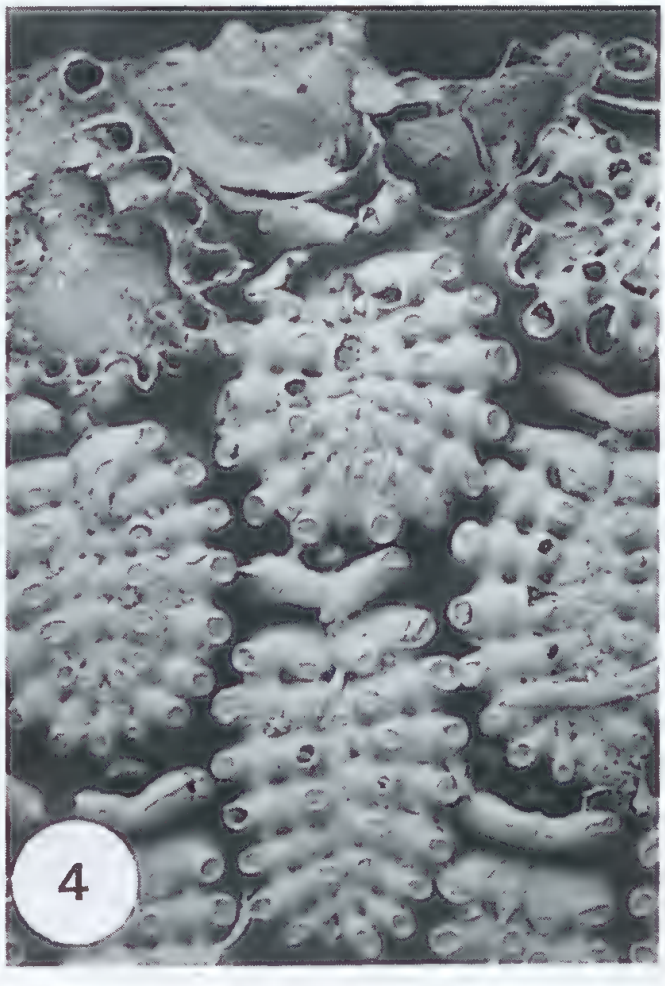
Corbulipora MacGillivray, 1895:60; Wass 1975:168; Bock & Cook, 1994:33; in press.

Corbulipora inopinata **sp.nov.**
(Figs 1–6)

Material Examined: HOLOTYPE MOV, F80665, GAB Stn 049, subcolony including phase-2 developing into phase-3 and then repeating phase-2.



FIGURES 1–2. *Corbulipora inopinata* sp.nov. **1**, subcolony showing phase-2 autozooids and two ovicelled zooids at the proximal end (arrowed). Intermediate zooids leading to two astogenetic generations of phase-3 zooids at the growing tip (GAB Stn 049) X22; **2**, phase-3 subcolony with marginal pore chambers and autozooids with occluded orifices (GAB Stn 020) X40.



FIGURES 3–4. *Corbulipora inopinata* sp.nov. **3**, phase-2 zooids with ovicells and simple frontal spines (GAB Stn 049, see also Fig.1). X80; **4**, phase-3 zooids with complex frontal shields (GAB Stn 049, see also Fig.1) X70.

Paratypes: Rest of material, including SAM L755, GAB Stn 049 part.

Description

Corbulipora with colony including three subcolony phases. Primary phase encrusting, ancestrula not seen; primary triad zooids with frontal shield of 16 simple spines. All zooids with a distinct, smooth gymnocyst, and communicating through small pore-chambers. Remaining primary-phase zooids with frontal shields with 16–18 spines, separated by 3–4 series of small lacunae and with two concentric series of raised pelmatidia. Calcified orifice with 3 spines, lateral pair often bifid. Second, flustrine phase inferred to arise from primary phase. Fronds developing from stalk kenozooids and elongated autozooids, often in quadriserial groups; series bifurcating to form fronds 10–12 zooids wide and 150 astogenetic generations long, bifurcating up to 4 times. Autozooids with distinct gymnocyst and 14–16 flattened spines overarching the frontal membrane. Brooding zooids with enlarged, curved, sometimes medially fused oral spines and large hyperstomial ovicell. Ovicell frontal with median suture and paired entooecial areas. Avicularia scattered, rare in presence of ovicells. Rostrum elongated, narrow, not raised distally; slightly expanded and rounded terminally, mandible hinged on a delicate bar, orientated distally. Tips of fronds with 3–4 astogenetic generations of zooids with intermediate morphologies leading to the third, bilaminar phase subcolonies. These form small, expanded groups of zooids with shields similar to phase-1 subcolonies, with two concentric series of raised pelmatidia. Zooids have a small orifice, sometimes partially occluded by the fusion of enlarged oral spines. Numerous rhizoids develop from marginal pore-chambers, together with stalk kenozooids and elongated stalk autozooids with a small opesia and marginal spines, which are the origin of repeated subcolonies of phase-2.

FIGURES 5–6. *Corbulipora inopinata* sp.nov. **5**, phase-2 autozooids, note enlarged pair of distal spines (GAB Stn 098) X100; **6**, phase-2 autozooids and avicularium (GAB Stn 098) X80.

Etymology

Inopinus L. — unexpected: referring to the occurrence of a second Recent species of *Corbulipora* with multiphase growth.

Remarks

The three phases of *C. inopinata* resemble those of *C. tubulifera* closely, but differ in several respects. The most noticeable difference is in the occurrence of a spinous shield in the autozooids of the second, flustrine phase. The spines are flattened and generally do not fuse centrally, although the enlarged suboral spines of marginal zooids may be fused. In addition, the avicularia of *C. inopinata* are much narrower, and are not raised distally, as are those in *C. tubulifera*, and the mandibles are hinged on a delicate, but complete bar. The palate is much longer in proportion to the proximal gymnocyst than in *C. tubulifera*. Other differences are small, but distinct and consistent. Although no ancestrula has been preserved, one of the small, phase-1 colonies encrusting *Turritella* from Stn GAB 083 possesses a post-ancestrular triad of very small zooids. These all have a shield of simple spines, very similar to the one post-ancestrular zooid of the triad in *C. ornata* (Bock & Cook, in press, fig. 1). Subsequent zooids have two series of pelmatidia, which do not develop until later in astogeny in *C. tubulifera*. The orifices of this stage are also wider than those of *C. tubulifera*. No stalk zooids have been preserved arising from the encrusting phase in *C. inopinata*, but by analogy with *C. tubulifera*, these are presumed to be identical with those which arise from phase-3 bilaminar subcolonies. These consist of one or two pairs of kenozooids 2.5mm long, often accompanied or succeeded by one or more pairs of elongated zooids 2mm long, each with a small opesia surrounded by 8–12 short, simple spines. Thus the stalks differ from those of *C. tubulifera* in being more robust, with more zooidal elements, and in the occurrence of autozooids with an opesia, rather than kenozooids, early in astogeny. The zooids of intermediate morphology at the tips of the flustrine phase-2 fronds attain a complete

shield of phase-3 autozooids within 4 astogenetic generations. First, the flattened spines fuse medially, leaving a row of small lacunae. A single series of pelmatidia develops on the spines of the next generation of zooids, and a paired series, with 3–4 lacunae, develops on the shields of subsequent generations. The small calcified orifice is complete within the next generation or two. Although the general appearance of the autozooids of the bilaminar phase is very like those of *C. tubulifera*, they have a smaller orifice. Although these are often partially occluded by the oral spines, they do not usually exhibit the series of changes resulting in complete closure of the orifice which occurs in *C. tubulifera* (Wass 1975). In one specimen from GAB Stn 020, the spines are enlarged and nearly occlude the orifice (Fig. 2).

One of the specimens from GAB Stn 013 illustrates the relationship and probable functions of phase-2 and phase-3 subcolonies particularly well. It consists of a small bilaminar phase-3 subcolony comprising approximately 60 autozooids. More than 50 rhizoids arise from the marginal pore-chambers, and on one face of the subcolony these are involved with and adhere to minute shell and bryozoan fragments. On the edge of the other face, one quadriserial stalk, 15mm long, consisting of two generations of quadriserial kenozooids and 10–12 generations of elongated autozooids, gives rise to a phase-2 flustrine subcolony about 30mm long, with more than 40 astogenetic generations. It seems almost certain that the one face of the bilaminar phase was buried in the surface sediments, whereas the flustrine frond extended above the surface. This subcolony is quite small; two flustrine subcolonies from Stn 056 extend up to 70mm and include 10,000 to 12,000 zooids, many of which are ovicelled. These would protrude well above the surface of the bottom sediment, allowing the larvae to be released easily.

The similarities in phase structure found in *C. inopinata* and *C. tubulifera* reinforce the inferences previously made by Bock and Cook (1994; in press) as to the nature and relationships of the known phases in *C. ornata* and *C. suggerens*, from the Victorian Tertiary. They also strongly suggest that the ovicellate phase of *C. suggerens* was a thinly calcified cellularine subcolony type, which has not been preserved as a fossil.

C. inopinata occurs in the western Bight together with *C. tubulifera*, but from shallower waters. In Bass Strait, and from Tasmania, *C. tubulifera* is known from a wide range in depth from 40m to 800m. It appears to be at the limits of its range south east of Eucla, in deep water. Wass (1975) first described *Corbulipora oriparma*, which is the bilaminar phase of *C. tubulifera*, from three localities. The holotype was from northeast Tasmania, the other specimens were from the eastern part of the South Australian coast. Subsequently, Wass and Yoo (1983) recorded *C. oriparma* from 12 localities, extending from near Perth to southwest of Eucla. These are similar to many of the localities from which specimens have been recently examined, and which have produced *C. inopinata*. None of Wass and Yoo's (1983) localities was from a greater depth than 158 m, far shallower than the most westerly known locality for *C. tubulifera*. Only examination of the specimens recorded by Wass and Yoo (1983) can decide their identity.

TABLE 1. Comparative measurements in mm of *Corbulipora inopinata* sp.nov. and *C. tubulifera* (Hincks). Lz, lz length and width of autozooid; lo, width of orifice; Lov, lov, length and width of ovicell; Lav, lav, length and width of avicularium; Lp, length of avicularian palate.

Character	*C. inopinata*	*C. tubulifera*
Phase 1 (including primary zooids in mms)		
Lz	0.41 – 0.70	0.45 – 0.74
lz	0.35 – 0.50	0.38 – 0.50
lo	0.12 – 0.17	0.10 – 0.13
Phase 2		
Lz	0.98 – 1.30	0.78 – 1.32
lz	0.26 – 0.29	0.25 – 0.33
Lov	0.21 – 0.23	0.23 – 0.27
lov	0.24 – 0.26	0.28 – 0.33
Lav	0.60 – 0.75	0.65 – 0.96
lav	0.15 – 0.17	0.22 – 0.26
Lp	0.43 – 0.51	0.31 – 0.35
Phase 3		
Lz	0.50 – 0.75	0.54 – 0.87
lz	0.37 – 0.50	0.32 – 0.54
lo	0.09 – 0.10	0.10 – 0.14

ACKNOWLEDGMENTS

We should like to thank Dr Yvonne Bone (University of Adelaide) and the Master and crew of CSIRO R.V. 'Franklin' for the opportunity for one of us (P.E.B.) to take part in the sampling programme in July 1995, which led to the discovery of the species described here. We are also grateful to Mr D. McDonald for his help in preparation of this paper.

References

BOCK, P. E. & COOK, P. L. 1994. Occurrence of three phases of growth with taxonomically distinct zooid morphologies. Pp 33–36 *in* Hayward, P. J., Ryland, J. S. & Taylor, P. D. (eds): Biology and Palaeobiology of Bryozoans. Olsen & Olsen: Fredensborg.

BOCK, P. E. & COOK, P. L. in press. A revision of the genus *Corbulipora* MacGillivray (Bryozoa: Cribriomorpha). *Memoirs of the Museum of Victoria.*

BUSK, G. 1852. Catalogue of Marine Polyzoa in the Collection of the British Museum. Part 1 Cheilostomata (Part).: viii, 1–54, vi. Trustees of the British Museum, London.

HINCKS, T. 1879. On the classification of British Polyzoa. *Annals and Magazine of Natural History*, (5) **3**:153–164.

MACGILLIVRAY, P. H. 1895. A Monograph of the Tertiary Polyzoa of Victoria. *Transactions of the Royal Society of Victoria*, **4**:1–166.

WASS, R. E. 1975. A revision of the Bryozoan Genus *Corbulipora* MacGillivray. *Proceedings of the Royal Society of Victoria* **87**:167–173.

WASS, R. E. & YOO, J. J. 1983. Cheilostome Bryozoa from the Southern Australian Continental Shelf. *Australian Journal of Marine and Freshwater Research* **34**: 303–354.

THE ARCHAEOLOGY OF LAKE SYSTEMS IN THE MIDDLE COOPER BASIN, NORTH-EASTERN SOUTH AUSTRALIA.

ELIZABETH WILLIAMS

WILLIAMS, E. 1998. The archaeology of lake systems in the middle Cooper Basin, north-eastern South Australia. *Records of the South Australian Museum* **30**(2): 69–91.

This paper presents the final report of a study of the archaeology of a number of lake systems located in the middle section of the Cooper Basin and neighbouring areas near Innamincka, South Australia. The paper outlines the results of archaeological fieldwork carried out during 1987 in one area within the region and relates this to other research undertaken in 1986 and 1989 in other parts of the middle of the Basin.

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The lakes forming the main focus of this study are located within an extensive linear dunefield, the Strzelecki desert, which forms part of Australia's continental dunefield. Although archaeological research has been undertaken along the main channel of the Cooper in the middle Cooper basin, particularly the Innamincka area (Hughes & Lampert 1980, McBryde 1987), the archaeology of the region's series of lake systems had not been studied until this research programme. Given that at least a number of the lakes hold fresh water for some considerable time, and that this is a strikingly unusual feature of arid areas generally, it is very likely that the lakes would have been the major focus of occupation for at least the recent period and possibly for extended periods in the past. As well, it is possible that landforms associated with the lakes such as source-bordering dunes preserve information about Pleistocene climates and changing environmental conditions, and possibly also about Pleistocene human occupation. A study of the lakes therefore had the potential to contribute to our knowledge of not only the recent occupation of the region but also that of past settlement, and possibly, the wider question of how Australia's arid zone itself was occupied.

In structuring the project, a preliminary analysis of the region revealed considerable variation of the nature and types of lakes. The study was designed to examine this variability in relation to human settlement. The study was designed as follows. I examined the archaeology of examples of the three major types of lake systems in the region. These are the semi-permanent lakes of the Coongie system, fed by the Cooper's North-West Branch; small isolated salt lakes marking the edge of the Cooper Basin, and a series of ephemeral lakes to the north of the Basin fed by local drainage and precipitation. The results of this work are presented below. In the latter sections of my discussion I compare this information with that obtained from sites located in a relatively waterless core of the dunefield located in the southern part of the Strzelecki desert. The concluding part of the paper outlines a number of speculative hypotheses about the occupation of the region and of Australia's arid zone in general.

Work carried out in the Coongie lake system has previously been reported on in Williams (1988) and that undertaken in the Strzelecki dunefield summarised in Smith, Williams and Wasson (1991). The current study draws this research together to present a comprehensive view of the region's archaeology.

General Environmental Features Of The Region, Including Those Important For Human Occupation

The study area lies in one of the most arid parts of Australia. The region is covered by an extensive linear dunefield and receives the lowest rainfall reading of any area of the continent (125 mm per annum). Despite the aridity there are reliable water sources here in the form of the Cooper Creek channel, its overflow system – the North-West Branch, and associated lakes fed by the channel systems. The amount of water in this drainage complex does not reflect local rainfall patterns and predominantly derives from received precipitation falling many hundreds of kilometres

to the north-east during the wet season in the upper parts of the Cooper catchment in north-west Queensland.

Given the arid setting of the region, water was a valuable resource and one of the most important features for human occupation. This is confirmed by the distribution of archaeological material within the Coongie lake system – site size and stone artefact density increases in relation to the location of permanent and semi-permanent water sources (Williams 1988: 59).

Another important feature for occupation was the availability of good quality stone suitable for artefact manufacture. Stone sources are extremely localised here and are either scarce or entirely absent within most of the linear dunefield itself. Some stone is available in the form of pebbles carpeting the surface of the gibber plains or 'stony deserts' located on the edges of the study area but this source only exists in the form of small nodules, not necessarily suitable for all types of artefact manufacture. The most extensive areas of stone are found in outcropping areas of hard rock within areas of dissected tablelands located on the margins of the study area.

Although the availability of resources such as water and stone were crucial, the two resources do not always coincide geographically. In the area immediately surrounding Innamincka where are found the extensive deep waterholes of the main Cooper channel and the abundant good quality stone resources of the locality's mesas and dissected tablelands, the two resources are abundant and lie close together. In the Coongie lakes system located within the stone-free linear dunefield, although water resources are extensive, good quality stone lies at least 60 km away. Therefore one of the major features of the archaeology of the region relates to how people balanced their need for stone with that for water and how this varied from one area to another. Because this feature is responsible for much of the patterning of the archaeology of the Basin and neighbouring areas, it is the major focus for this study.

A second and related focus concerns the antiquity of human occupation of the region. This topic is reported on in detail in Smith, Williams and Wasson (1991) and is also discussed here.

The structure of the paper is as follows. Given that the environment places such strong constraints on human occupation in the region, a general overview of climatic and geographic data is presented first, including material on environmental chronologies. This is followed by a brief summary of historical accounts of how Aboriginal people were observed to be using the area at the time of European contact, in order to present a picture of the occupation of the area at least for the recent past. The paper then reports on archaeological sites investigated, including an analysis of stone artefacts from a selected sample of sites. I conclude with a brief discussion of some of the theoretical implications of my work.

The Contemporary Environmental Setting

A number of the environmental parameters for the region have already been presented in Williams (1988). This section does not repeat this material and instead provides more detailed information on localities previously discussed and new data on areas not referred to in other publications.

The main focus of the study area is a series of lake systems within the Strzelecki desert. On the east and west the Strzelecki is bounded by stony country, comprising gibber plains and areas of dissected tablelands. The latter consists of the low, but locally steep escarpments and small mesas of the geological features known as the Innamincka and Cordillo domes.

The aridity of the area has been noted above. Precipitation in the region is unpredictable and erratic, with no systematic seasonal patterning. Evaporation is extremely high, at least one order of magnitude greater than precipitation (Reid and Gillen 1988: 16).

Three of the lake systems which form part of the study area are discussed in some detail here. They are the freshwater lakes of the Coongie system, a ring of salt lakes which mark the boundary of the Cooper drainage system, and another chain of lakes which lie to the north of the system and to the west of Cordillo Downs station. For convenience I refer to this latter group of lakes as the 'Cordillo lakes'.

The Coongie system

The Coongie system comprises a series of large, shallow, irregularly-shaped lakes lying within the linear dunefield. The lakes are fed by a tributary of the Cooper, the North-West Branch. The system has a complex hydrology and is described here in its constituent sections from south to north. Closest to the North-West Branch feeder channel are three lakes: Coongie, Marroocoolcannie and Maroocutchanie, which are fed directly from the North-West Branch. Two lakes lying further

FIGURE 1. Regional map of north-east South Australia showing the sites mentioned in the text.

FIGURE 2. Map of the Coongie and Cordillo lake systems.

north, Toontoowaranie and Goyder, are fed by interconnecting creeks from overflow from the first three lakes. To the north again are a further three lakes: Marradibbadibba, Lady Blanche and Sir Richard, which fill from overflow from Lake Goyder. In this paper I refer to all of the lakes collectively as the 'Coongie system'.

A further series of lake and channel systems also have some connection either to the Coongie system or the North-West Branch channel. It is noted that although they do hold water at certain times (as observed by the explorer, John McKinlay in 1862), the Coongie system, at least in the recent past, held the most extensive and most reliable sources of water. Little is currently known about their hydrology and for this reason the lakes do not form part of this study.

The North-West Branch which joins the Cooper west of Innamincka diverts most of the flow of the main Cooper channel northwards. For the area west of Innamincka relatively little water thus flows down the main Cooper channel on to Lake Eyre (Mike Steele, Innamincka store, pers. comm.). The Coongie system therefore catches most of the water coming down the Cooper channel. Flow down the Cooper derives from two sources: local precipitation and received rainfall which falls as far as 500 km upstream in the channel country of western Queensland. This latter precipitation falls mostly during the summer monsoon and contributes the major portion of the Cooper's flow. In contrast to local rainfall its timing is relatively predictable. Water from the summer monsoon rains takes about three months to come down the channel, first reaching the Coongie about late autumn (Barry Saunders, Innamincka region, pers. comm.).

Despite this level of predictability, the amount of water which actually comes down the channel and the exact time of year when it arrives markedly fluctuates in relation to variability in the timing and effectiveness of rainfall in the upper Cooper catchment. Nonetheless, there are predictable water sources in the form of deep, permanent waterholes which are often a couple of kilometres in length, located along the channels of the main drainage systems such as the Cooper and the North-West Branch.

With the possible exception of Coongie, the lakes do not hold water on a permanent basis. Oral tradition amongst current residents of the Innamincka region suggests that Coongie Lake itself holds water for most of the year, although the nature and amount of water it holds is difficult to quantify because of a lack of historical records. The other lakes in the system hold water for months at a time but the extent and duration is highly variable and depends on a number of factors. These include the amount of water coming down the Cooper from rainfall in the northern catchment, local precipitation, the position of the lake relative to the North-West Branch and the season of the year (evaporation is highest during summer).

Despite variability in the amount of water held in the Coongie system, the presence of often extensive supplies of fresh water in an otherwise extremely arid environment is extremely rare within Australia. The region consequently supports a very productive and diverse ecology, but one which varies in relation to water levels in the lakes and channels. The variability does not decrease overall productivity, and in fact is responsible for the high biodiversity of the region. The chain of lakes, with its complex sequence of rising and falling water levels is biologically highly productive. The lakes provide a diverse range of constantly changing habitats and have the potential to support the largest number and widest range of resources in the region. The major resources found here are: birds, especially waterbirds; fish, crayfish and mussels; dry-land and aquatic plants, and some mammal species.

Biological studies of the system reveal this very high productivity (Reid and Gillen 1988, Reid and Puckeridge 1990). Reid and Gillen for example recorded 161 separate bird species in the Coongie system and estimated that during the year under study (1986 – a wet year when all lakes in the system held water for much of the time) 20 000 waterbirds permanently occupied the lake chain. (1988: 184, 198).

Because of the interconnectedness of the system, rising and falling levels in one lake affect other lakes in the chain. Given that most of the plant and animal species in the region are oriented to specific environmental niches, variation in water levels consequently provides a much wider range of habitats than would otherwise be available along a permanent waterhole where water levels remain relatively constant. For example, although water levels in one lake may begin to fall with evaporation, certain species of waterbirds whose habitat is that of more shallow water will migrate in to the lake while those whose habitat is that of deeper water will move to another lake where water levels are rising. The differential fluctuation of water levels means that the lakes have the potential to carry the largest biomass of plants and animals in the region

because they are providing a wide range of ecological zones. The permanent waterholes on channels and rivers carry a relatively lower biomass because their environments are much less variable. Water levels fluctuate significantly less in these deep waterholes, supporting a smaller, but more predictable range of resources.

Salt lakes or 'salinas'

These irregular-shaped lakes lie in a ring along the northern and western boundary of the Cooper drainage basin and mark the boundaries of that system. They are located in the midst of the linear dunefield and are deflation hollows cut to groundwater level. This type of feature has been termed a 'salina' (Macumber 1980). Their salinity derives from the fact that in the region the groundwater is saline. Although no hydrological studies of the salinas in this area have been undertaken, it appears that for the recent past at least, they are permanently saline. In contrast to the Coongie system they therefore support relatively few plant and animal resources.

The Cordillo lakes

To the north of the Coongie system, beyond the salt lakes, lie another series of irregularly-shaped lakes. As with the salinas, no formal studies of these have been undertaken and there are no records of how often they fill.

Cartographic and field observations of the locality suggest that there are at least ten lakes in the system, connected by a series of channels. It appears that they fill from local run-off from the stony country of the Cordillo dome to the east. Their hydrology, unlike the Coongie system, therefore reflects local precipitation. The lakes were dry when fieldwork in the area was undertaken (1987), despite the years 1986 – 1987 having been much wetter than average in terms of local rainfall. This suggests that considerable local precipitation is required to fill them and they thus remain dry for very long periods of time. They are not salinas though, and small pools of fresh water were present in 1987 in a few places along the channels linking the lakes. The predominantly dry character of the lake system suggests that it supports relatively few plant and animal resources in comparison to the Coongie, but the presence of some areas of freshwater indicates that more resources are supported than the saline lakes.

The region's current environment is not necessarily the same as today as in the past. Over time there have been significant changes in climate, hydrology and landforms, with consequent effect on the human occupation of the region.

Past Environments – Dunefield And Floodplain Research

Much of the information on past regional climates has been summarised and presented elsewhere (Williams 1988) and so here I briefly refer to this work and also discuss new data which has arisen as a result of the study. R. Wasson has developed an environmental chronology for the region, based on stratigraphic sequences derived from longitudinal dunes and floodplain sediments (for references see Williams 1988). A summary of his findings and a discussion of their implications for the hydrology of the lakes follows.

Wasson's work indicates that before 22 000 years ago the Cooper had a higher velocity than today and was flooding out to a much greater extent. Although geomorphological studies of the Coongie lakes themselves have not been undertaken, Wasson's data suggest that if the Coongie system was in operation during this period it would have held considerably more water than today. As well, groundwater levels for the region as a whole would have been higher, indicating that the lake depressions which are now salinas may have held fresh water. Current work does not indicate whether local precipitation was also high at this time, so that it is not possible to model processes which may have been occurring in the Cordillo lakes.

Around 22 000 years ago, the Cooper's velocity decreased, flooding of the outer floodplain decreased and it is likely that the water table lowered as well. Consequently it is likely that what are now salinas would have changed from fresh water at this time. Lake levels in the Coongie system may have become lower. About 20 000 years ago conditions were windier and more arid, activating a period of dune building throughout the linear dunefield. The dune sediment was drawn from the deposits formed from the continuing, reduced flooding of the outer floodplain. These climatic conditions and the consequent dune building persisted until around 16 000 years ago. At about 12 500 years ago the flooding-out of the outer floodplain ceased, removing the sediment available for dune building.

Dune building began again in the later Holocene, although on a smaller scale than in the late Pleistocene. Wasson (1986: 79) notes that this event is enigmatic, since in contrast to the late

Pleistocene there seems to have been no climatic change occurring on a scale large enough to be able to mobilise sediments. He has speculated that it is possible, although not yet conclusively demonstrated, that the phenomenon could be related to more intensive human occupation of the region. If such intensive occupation took place, the erosion resulting from Aboriginal firing of vegetation to aid the procurement of food resources, together with clearing of trees and other vegetation to provide fuel for campfires and earth ovens, may have caused greater mobility in sediments.

Past Environments – Studies Of Lakeshore Features

The environmental data presented above is derived from a study of dunefield and floodplain sediments and presents a broad regional chronology. Is it possible to develop a chronology for the lake systems themselves?

A formal study of the geomorphology of the lake systems was beyond the scope of this study so I developed a smaller project, more complementary to the archaeological work. This involved an examination of whether landform features such as source-bordering dunes, which have the potential to contain information on lake chronology, had developed on lakeshore margins. These transverse dunes, Twidale's 'leeside mounds' (1972: 85–86), are similar to the lunettes of semi-arid regions. They are formed when longshore drift transports debris to beaches or lee shores of lakes. This sediment is then locally redistributed by the wind before being trapped by vegetation close to the lake margin.

The work was complementary to the archaeological survey in the sense that it was anticipated that source-bordering dunes were also likely to be a focus for human occupation. Systematic survey of these features would not only have the potential to reveal information about environmental features but also about human occupation, and the chronology of such occupation.

The project comprised an examination of examples of source-bordering dune features for each of the lake systems discussed earlier. Aerial photographs were used to identify the features and distinguish them from the linear dunes of the continental dunefield. The transverse dunes are paler in colour and generally trend east-west in contrast to the north-south longitudinal dunes. Once they were identified on the aerial photographs I travelled to them on the ground and systematically surveyed all exposures for any archaeological material.

Access to the features by vehicle was often difficult and in a number of cases access was by helicopter. Regarding the dating of the dunes it is noted that at the time the work was undertaken only radiocarbon dating was available to the study. Thus if organic material suitable for such dating was not present in-situ the dunes were unable to be directly dated. The results of the work are presented below.

The Coongie system

Information on a number of the source-bordering dunes of the Coongie system is outlined in detail in Williams (1988: 58–60). A summary of the work is presented here along with new data on other parts of the system.

The analysis of aerial photographs, maps and the survey work itself revealed that while some features such as colour of the source-bordering dunes are similar across the system there is major variability in the number, size and location of the features. A common feature is that all dunes are pale in colour and have little or no carbonate formation within their profiles, and they contain intermittent scatters of artefacts on their surface – typologically the artefacts appear to be late Holocene in age. All of these factors suggest the dunes are recent features. When cores of the dunes were exposed by erosion and these sections were examined, no organic or archaeological material was found in-situ, with the exception of one site at Lake Marradibbadibba – Lake Goyder 1. Details of this site are presented in Williams (1988: 60) where it is noted that it dates to the relatively recent past – 810–130 BP (ANU 5424) thus confirming the recent age of the transverse features.

There is considerable variation in dune shape and alignment across the system. Some lakes had a low and amorphous single transverse dune (such as Toontoowaranie); others had a higher and more distinct single dune (Coongie, Marroocoolcannie). Still others had multiple transverse dunes, one behind the other (five in the case of Lake Lady Blanche, yet none on the neighbouring Lake Sir Richard, and five or more in the floodplain between Coongie and Toontoowaranie). Location of dunes relative to lakes ranged from north, to north-east and east.

Given that the study of the dunes was only a preliminary one, it has not been possible to

determine what factors are responsible for the variation in dune features. It is likely that since there is major variation in the shape and size of the lakes themselves and how they fill relative to channel features and other lakes, and marked fluctuations in the amount of water coming into the system and the timing of when these events occur, it is probable that these factors are responsible for much of the variation.

The morphology and colour of the dunes indicates that they are of late Holocene rather than Pleistocene age. Two hypotheses could explain their recent age. The first proposes that the lake system was active in the Pleistocene, but since it is still in operation today, receiving what can be major flows of water and often flooding out extensively, any Pleistocene shore features have either been swept away by previous high-water events or are well buried below flood deposits. In 1974 for example, the entire system flooded out – aerial and satellite photography reveals water extending for hundreds of square kilometres with only the tops of linear and transverse dunes visible. Krieg and Callen note that the Coongie system is one of net sediment accumulation (1990: 60) and it is thus possible that many older lake-shore features have been disturbed or buried by sedimentation.

The second hypothesis proposes that the lake system may not have been in operation in the Pleistocene. Recent work by Callen and Bradford (1992) presents data showing that the current situation, in which most of the flow down the Cooper channel west of Innamincka is diverted north up the North-West Branch, may be very sensitive to minor changes in topology resulting from such factors as tectonic activity or shifts in sedimentation or the location of dune features (transverse and longitudinal). Slight movements on faults or in sedimentary features of only 1–2 metres within a large, low angle fan formed by the Cooper immediately west of Innamincka may be sufficient to create major changes in channel direction, and thus whether the Cooper flow is diverted either along the Branch, along another channel such as the main Cooper channel or even southwards down Strzelecki creek. Given this sensitivity to change it is possible that during the Pleistocene the North-West Branch may not have been carrying the main Cooper flow and the lakes may not have functioned as they do today.

Because a detailed study of the geomorphology of the Coongie system has not been undertaken it is not possible to resolve these competing hypotheses. It is nevertheless possible to conclude that whatever the reason, the lake-shore features currently exposed within the area do not provide a window onto the Pleistocene.

The salt lakes

Two of the larger salinas in the region, Coorie Coorie Tillie and Lake Deception, were chosen for analysis. Although the lakes lie some 100 km from each other, the form of their transverse dunes is virtually identical, in direct contrast to the variability of the Coongie system. As well, the transverse dunes themselves are very different to those of the Coongie.

Each lake has a low, flat, pale-coloured transverse dune on its northern edge. These have been extensively gullied to expose older-looking sediments which are redder in colour and more compact, with a pronounced carbonate horizon. It is likely that further analysis would confirm that the sediments are of Pleistocene age.

A systematic survey of the length of each dune, including an examination of the many sections of dune core exposed by erosion, revealed that the small amount of archaeological material present all lay within recent sediments on the dune surface, rather than in the Pleistocene core.

In contrast to the Coongie, there are no large amounts of water coming into the system to modify or distort landform features. The salinas are groundwater features, and do not fill from any channels. The dunes' consistency in nature and form could result from similarity in formation and hydrology operating on the lakes. Unlike the Coongie, the transverse dunes appear to have the potential to preserve Pleistocene sediments but no stratified archaeological material is currently visible within their profiles.

The Cordillo lakes

This system has a set of source-bordering dunes different from both the Coongie system and the salinas. Like the salinas and unlike the Coongie system, there appeared to be a strong consistency in the number, form and structure of the features across the lake margins.

On the northern edge of the lakes is a sequence of three transverse dunes trending east-west, and located one behind the other. The dune closest to the lake edge is quite low, less than a metre in height and pale in colour. Behind this is another, slightly higher, pale-coloured dune which is beginning to blow out into small longitudinal dunes. Behind this again is another higher dune, distinctly orange in colour with a pronounced carbonate horizon, which has almost completely blown out into longitudinal dunes.

The outermost dune is heavily eroded and it is likely that it is Pleistocene in age. Samples of carbonate from within the profile of the dune from Lake Koonoomorinna were dated using radiocarbon techniques and returned the relatively recent dates of 3930–80 BP (ANU 6182) and 4560–80 BP (ANU 6182). John Head of ANU Radiocarbon Laboratory notes that the samples are not dating the formation of the dune itself, only the last major phase of mobilisation of carbonates within the dune. Such mobilisation would have taken place during the last period of stable high-water levels in the region and the samples are probably dating this event (pers. comm.).

A complete survey of all of the dunes from one lake, Koonoomoorinna, revealed that stone artefacts are scattered across the surface of each dune, but that no artefacts or organic material were present in-situ within the cores of the features, including the Pleistocene dune. An analysis of a number of samples of the artefacts is presented later in the paper but it is noted here that those seen had features characteristic of artefacts dating to the mid-late Holocene.

It is suggested that the regularity in source-bordering dune spacing and form for the Cordillo lake system is, like the salinas, reflecting consistency in processes involved in formation and filling. The lakes fill from run-off within the local catchment, and in contrast to the Coongie system there is significantly more regularity in their hydrological processes and many fewer flood events to affect the morphology of lake-shore features. Like the salinas and in contrast to the Coongie system, the transverse dunes appear to have the potential to preserve Pleistocene sediments but, as with the salinas, no in-situ archaeological material is currently visible within their profiles.

It is not known at this stage why the lakes preserve a group of three transverse dunes. Each dune may reflect a period of relative stability in lake levels so that the position of the dunes, one behind the other, may indicate a shrinking lake basin since higher levels in the later Pleistocene. Alternatively, the position of the dunes may reflect the fact that all lakes in the region, including the Coongie system, are slowly migrating southwards over time (Bob Wasson pers. comm.). The presence of the dunes may reflect both factors.

Following this presentation of climatic and environmental information, the next section places the region in a more recent context by summarising historical accounts of how Aboriginal people occupied the area at the time of contact with European people. The section draws on information presented in Williams (1988) and Layton, Foley and Williams (1991: 258–259) and also presents new material.

Historical Accounts Of Subsistence And Settlement

Citing McKinlay (1862), who was the first European to travel through the entire middle Cooper lake system, the region was densely populated at the time of contact. McKinlay's expedition, which was one of those initiated to search for Burke and Wills, involved the party spending several months in the lake system in 1861–1862. During this time they were systematically examining each of the lakes and channel systems of the North-West Branch in their search for the missing explorers.

McKinlay saw more than 700 people in the region during his travels, including more than 300 people camped along Hamilton Creek, immediately west of Lake Toontoowaranie in the Coongie system, 200–300 people along the North-West Branch just south of Coongie Lake itself, and at least 150 people around Lake Lady Blanche (1862: 37, 38, 46). Because of the length of time he spent in the region he was also able to observe how people utilised fluctuations in water levels across the lakes.

McKinlay's information shows that population densities were highest around the large, permanent waterholes on the channels of the North-West Branch and the Cooper itself, and those lakes within the North-West Branch system which were currently holding water. Group composition appears to have been relatively fluid. Large aggregations of 150 or more were formed to take advantage of the flush of food resources which appeared as lakes began to fill. As they dried out again, people moved to other lakes, following the water, or split into small groups to harvest other resources or move on to other areas. Permanent or semi-permanent camps of between twenty and forty people were found along the permanent waterholes of the channel systems and this observation is also consistent with that of King, the surviving member of the Burke and Wills party who was cared for by Aboriginal people in the Innamincka region (Burke and Wills 1861). At these more settled camps habitations comprised substantial huts.

Important food resources were fish, crayfish

and mussels; waterbirds, and the variety of plant foods which germinated after flooding or local rain, especially nardoo. People favoured the lakes and rivers but after rain in the local catchment dispersed into small groups and travelled out into the drier dune country (McKinlay 1862: 49; Jones 1979). In these latter areas a flush of resources including small mammals, reptiles and certain types of plant foods, especially seed plants, appeared after the rain.

Although there are no ethnographic observations of how the Cordillo system was used, it can be hypothesised that after local rain areas such as this became a focus for occupation, the water sources it now held resulting in a relative abundance of food. It is also possible that if semi-permanent pools of water remained for a considerable time throughout the year in the shallow channels between the lakes, some small groups of people might have occupied the region on a more permanent basis.

While historical accounts mention the existence of the salt lakes there are no direct ethnographic observations of people using these areas. This implies that they were not favoured areas for occupation on a day-to-day basis.

Dealing with periods of resource stress

Although the Cooper lakes and channel systems contain a large range of food resources for much of the year, it appears that periods of resource stress were common, especially during droughts. Although there are no direct observations of the study area itself during these periods, historical material in Reuther (1981) provides information on strategies used by Aboriginal communities in the north-east of South Australia generally, to deal with the major fluctuations in environmental conditions characteristic of the region.

Reuther noted that when resources were abundant, for example in periods after rain, communities utilised natural surpluses in a variety of ways. Large gatherings were organised to take advantage of the abundance of food and these aggregations had the primary function of satisfying social obligations through, for example, trade and exchange (1981: vol. 1: 42, 47–48). As well as these activities, people harvested more than they needed for immediate consumption, processing and storing the surplus for later use. Seeds, fish and grubs were the resources most favoured for this type of processing (1981: vol. 1: 13, 47–48, 232, 273, 491; vol. 2: 547, 772, 835, 915, 927; vol. 4: 1852; vol. 7: 458, 549, 659).

As well as these measures to maximise the productivity of a region, according to Reuther the distribution of food resources was also artificially managed. He recorded that rats and caterpillars were moved from one area to another so as to increase stocks in particular regions (1981: vol. 2: 811–812; vol. 9: 232). Plant foods were propagated through the broadcasting of seed and the distribution of the branches of a particular vine species (1981: vol. 1: 107; vol. 7: 450). Areas of stream channels were dammed to increase stocks of fish (1981: vol. 8: 23). As well, certain localities were not utilised and were left in reserve for use during lean times, access to especially productive areas was strictly controlled and the boundaries of group territories were rigorously enforced (1981: vol. 1: 101, 123–128, 412; vol. 2: 559, 751, 1044; vol. 3: 1255, 1259). Transgressions, such as cases of people trying to obtain more food resources than their due, or attempting to accumulate resources, were severely punished according to Reuther, even by death (1981: vol. 1: 12–13, 123–129; vol. 2: 793–794). Further, instances were recorded of particular groups attempting to appropriate others' territory, sometimes successfully (1981 vol.1: 415; vol. 2: 896).

During times of drought people fell back to those areas which had water, and fish and stored food resources were the main foods consumed (1981 vol. 1: 520; vol. 2: 547, 616, 758, 915, 950; vol. 2: 1259; vol. 4: 1740). Although Reuther doesn't specify these areas, it is likely that the Coongie system and the Cooper channel near Innamincka were used in this manner.

Despite measures to counteract the effects of drought or a lack of surface water, local groups still suffered considerable stress. Reuther noted that many people perished at these times, from thirst, heat exhaustion or starvation (1981: vol. 1: 424, 535; vol. 2: 994–995, 1036; vol. 4: 1741–1742, 1926, 2108; vol. 8: 75, 118).

Factors Other Than Food Resources Affecting Settlement

It is a truism to state that it is not only the acquisition of food resources which affects the choice and nature of settlements. Access to raw materials necessary for the manufacture of goods and for trade, such as stone, wood, ochre, resin, bone, shell and the narcotic pituri, was another important determinant.

Historical accounts show that the Innamincka region was an important centre both for the

production of technological items, especially stone artefacts and for a related reason, as a crucial node in the vast exchange network which spanned the continent (Kerwin and Breen 1981: 286 and McBryde 1987). Innamincka was especially renowned for its extensive grindstone quarries (see Reuther 1981 vol.2: 899–900, McBryde 1987). The quarries, other important sites involved in the extraction of resources and the manufacture of goods, and the exchange networks of the Lake Eyre Basin generally, are currently being studied by McBryde and are thus not reported on here.

Although factors such as the utilisation of items for artefact manufacture and the location of trade and exchange networks are, as outlined above, crucial factors involved in settlement, not all of these features are equally archaeologically visible. For this reason I have chosen to look at one aspect that is more archaeologically visible than others, namely the characteristics of stone artefacts on lake-side sites and what these data, and other characteristics of the sites themselves, can tell us about Aboriginal use of the region. As outlined, stone suitable for the manufacture of artefacts is not uniformly distributed across the region and with the exception of Innamincka, stone sources and water sources do not generally coincide.

Two main sources of stone are present in the study area. Silcrete, chert and chalcedony are found as smallish pebbles on the surface of gibber plains, while better quality and more extensive areas of hard rock, comprising outcrops of chert, chalcedony, silcrete, quartzite and sandstone are found within the geological features known as the Innamincka and Cordillo domes (South Australia Department of Mines and Energy staff: pers. comm. and personal observation). Discrete areas of outcropping hard rock also occur within the linear dunefield south of the Cooper channel and east of Strzelecki creek (see Smith, Williams and Wasson 1991: 185).

Although there are no historical accounts of how Aboriginal people in the region quarried and used stone, apart from Reuther's observations on the Innamincka grindstone quarries, field observations and geological data can be used to determine what may have been favoured sources. It appears that while gibber pebbles were utilised, this took place on a relatively limited basis compared to other sources because of the relatively small size of the nodules of stone that could be worked. Outcropping areas of hard rock were thus favoured over gibber pebbles because they provided larger fragments of stone and were more uniform in quality. As well, certain types of stone such as sandstone were not available as pebbles and were only located within hard rock localities.

Using data from geological mapping of the region and advice from South Australian Department of Mines and Energy staff, it is estimated that the Coongie system lies at least 60 km from good quality stone sources while the Cordillo lakes lie at least 20 km distant. Particular stone sources which would have been favoured include: the silcrete (including chalcedony, cherts, cherty silcretes and quartzites) of the Cordillo surface which caps the mesas and cuestas of the Cordillo and Innamincka regions and also includes the silicified Eyre formation and the silicified Winton formation; the Eyre formation which includes sandstones suitable for grindstone manufacture, and also small pebbles of agate and fossil wood, and the Cadelga limestone which includes a cherty limestone.

Surrounding these outcrops of hard rock and extending outwards for five kilometres or so are areas of gibber containing pebbles and larger blocks of stone eroded from these formations. Some of this material would have been utilised as well.

A Model For Archaeological Site Distribution Within The Lake Systems

Historical observations can be combined with information on the availability of stone to present a model of how the lake systems were utilised. The model makes a number of assumptions, namely that there is a relationship between the availability of water and food resources; and intensity of occupation as reflected by the size and nature of archaeological sites. Cutting across these factors are others relating to the availability of stone, the most common material found on sites. Using models developed by other researchers such as Hiscock (1987), it is hypothesised that there will be a general correspondence between the morphology of artefacts on a site and distance from the stone source. These models predict that as one moves significant distances from stone sources, characteristics of extreme reduction of stone material will be found in assemblages such as recycling, rejuvenation and rationing. Combining these different models, we can develop a unified set of hypotheses regarding the patterning of archaeological material.

The Coongie system

The Coongie lakes, with their abundance of food sources, and availability of water for at least part of the year, were areas with a high population density relative to other lakes in the region. Large and diverse occupation sites will be found in those areas which contain the most predictable and extensive areas of water. Such places include the permanent waterholes on the channels, the inlets to lakes, and those parts of the lakes that are deeper relative to the rest of the lake basin and thus hold water for a longer period of time. These latter areas are found on the southern margin, since as outlined above, the lakes in the region are slowly migrating southwards, cutting into longitudinal dunes on their southern shore. Their southern end is thus their deepest section.

It is anticipated that given the known high population densities of at least the recent past, there will be a correspondingly high density of archaeological material (especially stone artefacts) on the large, favoured occupation sites. It is likely that on these sites people would not have moved as much compared to areas which contained less predictable resources. We can therefore expect evidence for the manufacturing and maintenance of tools such as stone artefacts. Given that the sites were used on a longer-term basis we can also expect a higher proportion of formal tool types than on sites with more unreliable water sources, and a greater proportion of finer-grained, good quality stone. As well, it is likely that a relatively larger number of artefacts will have edge damage from activities such as trampling, because of high population densities at the sites and residential stability (Scott Mitchell pers comm).

Because it is possible that people from other areas may have been using these localities as refuges in times of resource stress, it is also expected that these places will contain a wider range of raw material than at other sites, including stone brought in from other regions. Because stone sources lay some considerable distance away (60+ km), primary reduction was unlikely to have been undertaken here and the stone may have been 'rationed'. Cortex, an indication of primary reduction, will be rare on pieces. Flakes and cores will be small in size and noticeably reduced. High population densities and length of site occupation may have exacerbated the incidence of rationing, so that these features will be particularly marked at the large sites near permanent or semi-permanent water.

The salt lakes

Given the absence of fresh water in these localities it is anticipated that they were not favoured as occupation sites. In times of high local rainfall it is possible that the lakes may have filled to some extent with rainwater run-off from the surrounding dunes. At these times salt levels may have decreased and they might have been used on a temporary basis as people pushed out into the dunefields after rain.

The salt lakes may have had another role, as navigation aids for people travelling through the dunefield. They are often the only notable features present within extensive areas of dunes and are visible for some distance because of the sun sparkling on the salt surface.

I conclude that the sites were used, albeit on a much more limited basis than the Coongie and Cordillo system. It is likely that groups using them were small in size and highly mobile. There is likely to be a correspondingly low density of artefacts, relative absence of formal tools, a more limited range of raw material types present and a lower proportion of good quality fine-grained raw material on occupation sites. Little manufacture or maintenance of artefacts will have been carried out on site. Given that the lakes are often well within the dunefield and thus some distance from stone sources, the stone discarded here will have been noticeably reduced.

The Cordillo lakes

With their better resources than the salt lakes the Cordillo lakes are likely to have been the subject of more intensive occupation but on a less pronounced basis than the better-watered Coongie system. It is anticipated that sites will be smaller in size than in the Coongie and fewer artefacts will be present. Because people occupied these sites for shorter periods of time it is expected that there will be less evidence for the manufacturing and maintenance of stone artefacts. A lower number and a smaller range of formal tool types will be present, and there will be less variation in raw material type. Larger sites are more likely to be located in areas of more predictable water and food resources such as the inlets to lakes or the small waterholes on channels.

Given that the Cordillo lakes are closer to raw material sources than the Coongie it is expected that stone artefacts will not be reduced as much. Cores will be more common and cores and flakes

will be heavier and larger in size, on average. A higher proportion of flaked pieces will contain cortex.

The Archaeological Surveys: General Archaeological Features Of The Lake Systems

Before presenting material on the archaeological sites examined as part of the study I will outline some of the factors affecting the location and recording of archaeological material in the field.

The visibility of archaeological material, especially stone artefacts, is reasonable compared to many other areas. The aridity of the region means that dense vegetation is often absent and much of the ground surface is exposed. This also means that stone sources are relatively straightforward to detect. Open sites are the major archaeological site type in the region because rock formations which form rock shelter sites are extremely rare here. Only one shelter (a very small and shallow one located near Innamincka) is known for the whole region. Although open sites are the major site type available for analysis, given the good ground surface visibility this is not necessarily the problem that it is in other regions. Stratified sites are extremely rare nevertheless and it is often very difficult to determine whether archaeological material is unequivocally in-situ, has been deflated down from other units, or otherwise re-deposited.

I will present general features of the archaeology of the lake systems first and compare them with my model. In the following sections I will discuss more detailed analyses of assemblages from a sample of collected sites so as to make a comparison between localities within the region.

The Coongie system

The results of this work are presented in Williams (1988) and are briefly summarised here, along with other material from 1987 surveys. Before outlining this information it is noted that not all of the lakes in the Coongie system were surveyed for archaeological sites. Coongie itself was not examined because it was already being systematically surveyed by a team of archaeologists from the South Australian Aboriginal Heritage Branch, (now within the Department of State Aboriginal Affairs), in relation to the development of a management plan for the region. The results of that study are not yet available for analysis. Lake Goyder was not examined because in the years which formed the subject of my fieldwork (1986–1987) the lake was flooding out and thus conditions were not conducive to archaeological survey.

The most common site type around the lakes surveyed for the study comprised scatters of stone artefacts. In all sites surveyed these scatters were either located within upper recent sediments or appeared to have deflated down from such units to sit as a lag on more compacted surfaces. On many of the sites, scatters of freshwater mussel shell were also present. Although not all the margins of every lake were examined, it appeared that stone and shell was present as an intermettent scatter intermittently around the margins of lakes that were surveyed (Toontoowaranie, Marroocutchanie). These were often present as small scatters of shell with numbers of artefacts, similar to Meehan's (1982) 'dinnertime camps'. Artefact density and site size increased as one approached permanent water sources and the largest sites were found in the areas outlined earlier – permanent waterholes on the channels, the inlets to lakes, and the deeper, southern margins of the lakes. These latter sites often incorporated extensive scatters of shell as well. Compared to the large sites, site size and density of material was comparatively low on the pale-coloured transverse dunes. On these sites stone artefacts and scattered termite mound hearth fragments were the most common form of material.

Typologically, most, if not all artefacts dated to the mid to late Holocene. The main types noted were tula adzes and adze slugs, points, backed blades, small scrapers, cores, flakes and fragments of large, flat grindstones of the type described by Smith (1986). As well, single examples of large, cube-shaped silcrete cobbles which were commonly ground on one or more surfaces and in some cases also had flakes removed from edges and had thus been used as large cores, were often also present. Raw materials favoured for artefact manufacture were chalcedony, chert, cherty silcrete, a coarser-grained silcrete, and quartzite.

Other artefacts such as edge-ground axes and flaked pieces of quartz crystal were also found but appeared to be restricted in distribution to the lakes most difficult to access by vehicle. It appears that such artefacts were formerly present on other lake-side sites but, together with other types of artefacts such as complete grindstones, have been removed by collectors (a conclusion supported by oral tradition in the region and also personal

observation of collections held by individuals resident in the region).

Apart from the occasional large silcrete cobbles and remaining grindstones left on sites, stone artefacts were mostly small in size and appeared to be noticeably reduced. As well, although density of stone material varied with location, even on sites with comparatively higher numbers of artefacts, density was still relatively low compared to artefact scatters found in many other parts of the continent. On the larger sites average density for collected sites was of the order of 6–8 artefacts/square metre while on the smaller sites maximum densities were only 2–4 artefacts/square metre.

Occasionally larger flakes and horsehoof cores were found on sites or located as isolated finds within the dunefield or near lakes. There appeared to be no consistency in their location though and these were often in association with artefacts that typologically dated to the mid to late Holocene. As well, they were not noticeably patinated or weathered, and did not appear to be derived from Pleistocene sedimentary contexts, suggesting that most of these are mid to late Holocene in age.

Hearth material, usually fragments of burnt termite mound, was often scattered across sites and isolated hearths were also present. The amount of hearth material rose in density on the larger sites and on these latter places fragments of bone (mostly that of fish and small mammals) were often found as well. The large sites are indeed extensive – examples up to 10 000 square metres and 7 000 square metres in extent respectively are described in Williams (1988: 59).

Dating of material on sites confirms that implied by the typology of artefacts, that is, of the late Holocene. Details of radiocarbon dates are provided in Williams (1988).

The archaeological data is consistent with the ethnographic observations that the Coongie lake system was extensively used and densely populated. The presence of good quality raw material and a range of artefact types, including formal tools and manufacturing debris, suggests that residential stability could have been fairly high in comparison to other areas. This is also supported by the wide range of archaeological material present, including bone and shell. The small size and marked reduction of artefacts indicates rationing of raw material was taking place and this is consistent with the distance of the area from stone sources.

The salt lakes

As expected, within the areas sampled for sites for Coorie Coorie Tillie and Lake Deception, archaeological material existed in very low densities. At Coorie Coorie Tillie for example, along the 5 km stretch of the transverse dune on the northern margin of the lake only five isolated artefacts were seen: three amorphous flakes, one tula slug and one small core. All artefacts were manufactured from silcrete. Archaeological material was similarly rare at Lake Deception. Sites comprising occasional small, discrete groups of artefacts were found in the vicinity of both lakes but not within the transverse dune systems. Instead they were set back one or two longitudinal dunes from the lake margin, on the surfaces of small claypans.

The sites found in these areas comprised small (mostly less than 30 artefacts), discrete scatters of stone artefacts. Density was very low, much less than 1 artefact/square metre. Neither mussel shell nor animal bone was present on these sites or on other parts of lake margins but occasionally examples of isolated termite mound hearths were found in association with the stone artefact scatters.

One of the termite mound hearths at Coorie Coorie Tillie was dated. To examine particular features of the region's environment which may be affecting dates, the material was separated into a humic and non-humic fraction and each sample separately dated. The humic fraction returned a date of 1150 180 BP (ANU 6181) and the non-humic: 710 170 BP (also ANU 6181). The disparity in the dates can be explained as follows. John Head, ANU Radiocarbon Laboratory, confirms that the non-humic fraction, comprising clay particles, binds to younger carbon and clay material, biasing the date and making it too young. To account for this the non-humic fraction, which although comprising polymers which can incorporate younger carbon, was treated with solvents so as to extract the older carbon which is more likely to be reflecting the true age of the sample (pers. comm.). The older carbon is dated and the result, 1150 180 BP, is the best estimate of the sample's true age.

Apart from the differences in density and site composition from the Coongie sites, other distinguishing features were also apparent. Most of the artefacts were manufactured from a relatively restricted range of raw material, assemblages being dominated by a grey, comparatively coarse-grained silcrete. Some cores were present and also occasional formal tool types such as tulas, scrapers or points. Artefacts appeared to be noticeably larger than those at

Coongie. Because of the low density of material, and also given the difficulty of access to the sites, collections of artefacts were not made when the sites were visited and so a more formal comparison between these features and other lake systems is not possible. The low density of material present on these lakes suggests that while they were utilised, they were not favoured for occupation. The restricted range of raw material found, its contrast in quality to the fine-grained material found on the Coongie system and the relative absence of manufacturing debris, indicates people used these areas on an opportunistic basis. The low numbers of artefacts present also suggests that group sizes were relatively low.

The Cordillo lakes

Vehicular access to the lakes was difficult because of their remote location and thus only one lake, Koonoomoorinna, was surveyed in detail. Reconnaissance trips to other lakes in the region revealed that the general patterning of sites on this lake is similar to that on others.

As for other parts of the study region, the most common site types seen were scatters of stone artefacts. Formal tool types were similar to those observed on the Coongie sites, comprising tulas and other adzes, scrapers, points, fragments of grindstones and the large silcrete cobbles with ground and/or flaked surfaces. Formal types did not appear to be as common within assemblages as for the Coongie and no shell or bone was present on sites. The range of raw material did not seem as extensive and finer grained raw material such as chert and chalcedony was found in lower densities. Artefacts appeared to be larger in size and not as heavily reduced.

Hearths were also not as common and no hearth sites were observed on any of the sites ringing the immediate margin of the lake. A small number of hearths were found in the inter-dune corridors one or more dunes back from the lake margin. One, comprising burnt calcrete nodules, was dated and returned a 'modern' radiocarbon age (100.2, 1.8 %M, ANU 6183), although this sample may have been contaminated by younger carbon from the surrounding locality (John Head pers. comm.).

The densest, most extensive scatters of artefacts were found in those areas with the most reliable sources of water – inlets, the southern margin of lakes, and on the edges of possibly semi-permanent waterholes along the channels which connect the lakes. A large scatter along one of the channel waterholes contained a number of hearths. Intermittent, low density scatters of artefacts were found along the lake margins and on the transverse dunes to the north.

The archaeological patterning is consistent with the hypothesis that the Cordillo lakes were utilised more than the salt lakes but less than the better-watered Coongie area. This is supported by the fact that the Cordillo sites contained a smaller range of archaeological material than the Coongie sites (no shell or bone, hearths not as common, a lower density of formal tool types and of better quality stone). The relative lack of reduction of artefacts could indicate either less residential stability or a closer distance than Coongie to raw material sources, or both.

Now that I have presented general observations of the archaeology of the lake systems I will outline the results of the more detailed comparisons between sites. This work provides a more fine-grained analysis of differences that may exist across lake systems and between systems.

More Detailed Comparison Of Assemblages From Individual Sites

Because of the relatively low density of artefactual material within the region, for reasons of statistical analysis I only made formal collections from large sites. The sites analysed in this way are outlined below, along with the results of the analysis.

Before discussing the sites it is noted that although some of the analysis of the material was published in a preliminary form by Smith, Williams and Wasson (1991, see for example Tables 11 and 12), a number of the figures in that paper vary slightly from those presented in this publication. This is due to the fact that the results of the analysis of the Coongie sites outlined in the 1991 paper were only at a preliminary stage. The material presented in the current paper reflects the completed analysis of the assemblages.

Sites chosen for analysis

Five sites were chosen for analysis: Marroocoolcannie 2 (MCO 2), Toontoowaranie 1 (TTW 1), Lake Lady Blanche midden (LLB), Koonoomoorinna inlet (KOI) and Koonoomoorinna second white transverse dune (KSW). The first three sites are located on Coongie lakes – their name indicates on which lake they are situated, and the latter two sites are located on the southern-most of the Cordillo lakes, Koonoomoorinna. All sites comprise large, discrete scatters of stone artefacts, together with

other material such as shell and bone in some cases.

The lakes were chosen for sampling and analysis to determine whether there were any major changes in stone artefact manufacture and discard across the Coongie system. Each site was chosen because it was the most extensive seen for the sampled areas of that particular lake. MCO 2 lies along the western margin of the channel feeding from Lake Marroolcoocannie to Lake Marroocutchanie. It covers an area of approximately 2 600 square metres and comprises a scatter of artefacts and shell deflating down from the uppermost recent unit of a pale, longitudinal dune. The material exists as a lag on a blow-out within the dune. At the western end of the site is a localised area of burnt shell and bone, the latter comprising the remains of fish and small mammal species. A hearth, which lies on the eastern part of the site, dated to 1130 110 BP (ANU 429).

A baseline was laid through the middle of the scatter so as to bisect both the area of burnt bone and the hearth. All artefacts along a strip 60 m along the baseline and 1 m either site of it were collected for analysis.

TTW 1 lies further to the north than MCO 2, located on the southern margin of Lake Toontoowaranie. It covers an area of 7000 square metres and comprises stone artefacts, shell and the remains of the collapsed, wooden framework of a domed hut, all lying on recent sediments on the top of a longitudinal dune. A sample of shell from the site returned a date of 330 80 BP (ANU 5425). A 20 x 2 metre grid was laid out within the centre of the scatter and all artefacts within this were collected.

LLB lies to the north and west of MCO 2 and TTW 1, on the inlet channel to Lake Lady Blanche, one of the terminal lakes in the Coongie system along with Lake Sir Richard. These two lakes hold water for a shorter period of time than those closer to the North-West Branch. When the lake was visited in August 1987 it was dry and had a salt crust on the lake floor. This was in contrast to the other Coongie lakes which were all full of water.

The site comprises a large scatter of stone artefacts, shell and bone extending for 12 000 square metres, eroding out of the uppermost units of a recent, white transverse dune associated with the inlet channel and flood-out zone of the lake. The bone comprises fish bone and golden perch otoliths. It is the largest and richest site in the inlet area. A 15 x 15 metre grid was laid out on the eastern edge of the exposure, where the densest scatter of shells, otoliths and artefacts was eroding out of the sand. All artefacts within the grid were collected.

The relative lack of water in the lake compared to others in the Coongie system reflects the distribution of sites in the area. Large sites such as this one, which are not only extensive but contain a variety of material, are restricted to the margins of the inlet channel. Isolated scatters of stone artefacts are found on the surface of the complex of at least five separate transverse dunes lying to the north-east of the lake, but these sites are small, discrete scatters of stone artefacts and do not contain shell, bone or hearth material.

Although the lake contains water on fewer occasions than others in the system, it was much favoured by Aboriginal occupants. McKinlay visited the lake in January 1862 and found it full of water, 'between five and six feet deep, and seven and three quarter miles in circumference ... and tens of thousands of pelicans on it ... with innumerable other birds ... and plenty of fish' (1862: 38). There was a large camp of at least 150 people on the lake when McKinlay was there and he observed that fish and 'nardoo' was their chief sustenance (1862: 42).

For the Cordillo lake, Koonoomoorinna, two areas were sampled for artefacts. Both sites, KOI and KSW were the most extensive discrete scatters of artefacts seen within the vicinity of the lake and this is why they were chosen for analysis.

KOI is a very extensive scatter of artefacts which follows the inlet to Lake Koonoomoorinna for several hundred metres. The site comprised stone artefacts only – no shell, hearths or bone were present. A small part of the site (10 m by 2 m) where the densest collection of artefacts was found, was gridded and a collection made.

KSW comprises a discrete scatter of artefacts lying as a lag within a blow-out in the second transverse dune north of the lake. Like KOI, only stone artefacts were present within the site.

MCO 2 and TTW 1 lie 65 km from sources of outcropping hard rock in the Innamincka dome and 60 km from the Cordillo dome sources. LLB lies 40 km from the Cordillo dome sources and 65 km from the Innamincka dome. KOI and KSW lie 30 km from the Cordillo dome and 90 km from the Innamincka dome.

For comparative purposes, the five lake-shore sites are compared with each other and also with one from the waterless core of the dunefield, site JSN. This latter site, which is reported on in Smith, Williams and Wasson (1991), comprises a scatter of stone artefacts and hearth material, and

Table 1. Characteristics of artefacts within assemblages, excluding ground pieces

Site	mean weight in gm, (sd)	% flakes	% cores	% formal tool types
KSW n=291	7.55 (17.57)	70.4	3.4	3.8
KOI n=308	5.14 (20.53)	48.4	4.2	2.6
LLB n=336	2.65 (7.11)	45.2	0.6	11.9
TTW 1 n=264	1.74 (3.33)	59.5	–	4.2
MCO 2 n=661	2.17 (8.32)	50.1	0.6	5.6
JSN n=407	6.6 (sd not available)	37.3	2.7	not available

is the only known Pleistocene site in the region. Hearths from the locality date to around 14 000, 10 000 and 2 500 BP. Associated with the hearths and lying as a lag on two inter-dune pans within longitudinal dunes is an extensive scatter of artefacts. Despite the Pleistocene dates for the hearths, analysis of the stone artefacts strongly suggests that they are late Holocene in age (Smith, Williams and Wasson 1991: 184).

JSN was chosen as a comparative site for the lakeside sites because it comprises the only known extensive scatter of stone artefacts for the core dunefield region. Most core dunefield sites only consist of an isolated artefact or very small scatters of stone artefacts (personal observation). The large size of the artefact sample (N = 407) from JSN and the fact that the artefacts appear to be late Holocene in age, similar in age to the lakeside sites, makes it the only comparative material currently available for the Coongie and Cordillo sites.

Table 2. Values of t for comparison between mean weights of artefacts

Site	KSW	KOI	LLB	TTW 1	MCO 2
KSW	–	–	–	–	–
KOI	not significant	–	–	–	–
LLB	t = 4.71	t = 2.11	–	–	–
TTW 1	t = 5.33	t = 2.72	not significant	–	–
MCO 2	t = 6.48	t = 3.22	not significant	not significant	–

Table 3. Mean weights of cores (gm)

Site	n	mean	sd
KSW	10	58.29	50.49
KOI	13	42.62	81.75
LLB	2	13.7	1.90
TTW 1	–	–	–
MCO 2	4	7.65	6.56
JSN	12	89.2	57.9

Table 4. Percentage of artefacts larger than 1 cm in length which contain cortex.

Site	% artefacts with cortex
KSW	12.4
KOI	11.0
LLB	4.29
TTW 1	9.2
MCO 2	3.2
JSN	20.0

Analysis of the sites

Broad characteristics of the stone artefact assemblages are presented in Table 1. As predicted by the model, the Coongie assemblages have features reflecting an extreme degree of reduction. Artefacts (all pieces of stone on the site worked in some way, excluding ground pieces) are extremely small in size (measured by mean weight in grams) and cores are very rare, or even non-existent in the case of TTW 1. The Coongie sites are very similar to each other but are different to both the Cordillo sites and JSN, which contain larger artefacts and a greater number of cores respectively.

The differences in mean weight between the

Table 5. Raw material composition of the assemblages (excluding small shatter < 1cm in length and including ground pieces)

Site	% Finer grained	% Coarser grained	% Very coarse grained (eg sandstone)
KSW (n=278)	47.1	41.7	11.2
KOI (n=239)	37.2	59.0	3.8
LLB (n=223)	72.6	19.3	8.1
TTW 1 (n=223)	66.4	27.4	6.3
MCO 2 (n=659)	59.8	23.7	16.5
JSN (n=401)	59.5	33.2	7.4

Table 6. Mean weights and mean lengths of complete flakes for different raw material types. Standard deviations are shown in brackets. Note: Only those artefacts > 1 cm in length have been included in this analysis because of the difficulty in determining whether smaller pieces were derived from finer or coarser-grained raw material. Ground pieces and sandstone have also been excluded from the sample.

Site	mean weight (gm) of complete flakes		mean weight (gm) of debitage >1 cm in length		Mean length (mm) of complete flakes	
	finer grained	coarser grained	finer grained	coarser grained	finer grained	coarser grained
KSW	3.9 (4.1)	12.0 (18.6)	3.2 (2.7)	7.4 (14.1)	25.0 (9.4)	31.7 (13.6)
KOI	2.3 (2.6)	6.71 (15.6)	2.3 (2.9)	5.0 (7.1)	17.8 (7.1)	25.2 (14.60)
LLB	1.3 (2.0)	2.1 (2.8)	3.1 (4.6)	9.3 (21.8)	15.8 (5.1)	19.1 (6.8)
TTW 1	0.9 (1.1)	4.8 (6.4)	1.0 (1.7)	7.4 (14.9)	15.8 (6.1)	26.3 (14.7)
MCO 2	0.9 (1.5)	8.0 (24.3)	0.9 (0.9)	3.5 (5.3)	15.2 (5.3)	23.5 (16.2)
JSN	3.1 (3.2)	4.7 (10.6)	5.6 (13.0)	3.5 (6.4)	not available	

Coongie and Cordillo assemblages are significant at the 0.05 level (Table 2). The figures for JSN are not available for comparison but it is anticipated that if they had been available, the mean weight of the assemblage would be statistically different to the Coongie sites but of the same order as the Cordillo assemblages.

As predicted by the model, the three groups of sites are very different in relation to the reduction of cores (Table 3). The cores from the Coongie sites are extremely small and, as outlined in Smith, Williams and Wasson (1991:187), very close to the theoretical limit at which bipolar techniques become necessary for further reduction. Consistent with this is the observation that in a further attempt to ration raw material, worked-out or small, broken cores have been recycled into small scrapers in the Coongie assemblages (N=9, mean weight = 8.2 gm, sd = 4.9). The Cordillo sites contain cores that are noticeably larger and heavier than those on the Coongie sites, while JSN contains on average larger cores again. There is no evidence that cores have been recycled as implements at either the Cordillo sites or at JSN.

The Cordillo sites contain proportionately greater number of flaked pieces with cortex than Coongie (Table 4), which is as predicted given that they lie closer to raw material sources, although the figures for TTW seem high in comparison to the other Coongie sites. The JSN assemblage contains an unusually high number of flakes with some degree of cortex. This feature is unexpected and as well as the relatively larger size of cores and flakes, indicates that the JSN assemblage shows neither the effect of relatively large distance from stone sources, nor mediating responses offsetting a diminishing stock of stone (see Smith, Williams and Wasson 1991: 187). This issue is discussed in more detail later in this paper.

Regarding raw material composition for assemblages, Table 5 shows that the Coongie sites contain proportionately more finer grained material (classified here as chalcedony, chert and cherty silcrete) than either the Cordillo sites or JSN and this is as expected (coarser-grained material has been classified here as granular silcrete and quartzite). Table 6 shows that flakes and debitage from fine-grained material are on average smaller in size and lighter in weight than those from coarser-grained material, but this does not explain all the variation in size between assemblages between sites in different areas. Fine-grained flakes and debitage from the Coongie sites are in virtually every case smaller in size and lighter in weight than fine-grained pieces from either the Cordillo sites or JSN.

As well as these trends, the Coongie sites also show a wider range of raw materials as predicted. MCO 2 has 13 major types of raw material, TTW 1 has eight types, LLB has seven, KOI has five and KSW has seven.

In terms of the artefact analysis it was decided not to differentiate artefacts with retouch from those where this feature appeared to be absent. This is because of the difficulty found in unambiguously identifying examples of retouched pieces within the Coongie and Cordillo assemblages. Numbers of artefacts within the assemblages contained what I recorded in my analysis as 'edge damage', where I describe this as an edge where very small flakes had been

removed and there is also a gloss or polish (visible under low-power magnification). However given the small size and thin cross-section of many of the flaked pieces it was impossible to determine whether this edge damage had occurred as a result of use, or as deliberate retouch, or from some other process such as flaking or trampling for example. Accordingly it was not possible to examine one of my hypotheses, that sites near more permanent water sources would show more edge damage from trampling.

Because of the difficulties in identifying what had caused the edge damage, none of the statistics for this feature have therefore been listed for this analysis. It is noted that in the assemblages examined there were very few artefacts with pronounced retouch (where this involved larger flakes being removed along an edge and/or very obvious polish) which did not also comprise a formal tool type such as a scraper, adze, point or backed blade. For the very few artefacts which did not fit in to a formal category they were nonetheless listed under 'formal types' in my tables.

Given that this classification methodology differed from that used for the JSN artefacts, it has not been possible to compare the two groups in a formal sense. Nonetheless some comparison are possible.

In terms of my category of 'formal tool types', the Coongie sites contain a greater proportion of these artefacts than the Cordillo sites (Table 1), as predicted. Adzes such as tulas and tula slugs formed the largest proportion of formal types in the Coongie sites (59% for MCO 2, 45% for TTW 1 and 55% for LLB). The remaining implement types comprised scrapers, points and backed flakes. For the Cordillo sites in contrast there is greater variation in the formal types of stone tools represented on sites. Adzes comprised 36% of the formal types present at KOI but only 18% of those at KSW. At KOI scrapers comprise the most common formal type (50%) while at KSW, points, backed flakes and backed blades are the most common type at 64%.

Regarding the artefacts comprising formal types, it was expected that examples will be more heavily reduced at sites near permanent water. Examining the largest sample of a formal type available, tula adzes and tula adze slugs, it is found that this is not the case. There is no clear trend in mean weights between the Coongie sites (MCO 2: mean = 8.5 gm, sd = 5.02, n = 15; TTW 1: mean = 3.25 gm, sd = 1.35, n = 2; LLB: mean = 14.18 gm, sd = 10.1, n = 19) or between the Coongie and Cordillo sites (KOI: mean = 3.7, sd = 1.0, n = 2; KSW: mean = 6.8, sd = 2.7, n = 2).

This suggests a number of factors. While overall characteristics of the assemblages presented in Table 1 show that stone was being curated and rationed in a very intensive way for the Coongie sites, the variability in size at discard for tulas and tula slugs, especially the relatively higher weights for the LLB site, suggest that occasionally the site occupants were not behaving as if raw material was as scarce as it appeared to be. This suggests that while certain factors such as the balancing of procurement of food and water sources with that of raw material is responsible for much of the variation seen on sites, people did not always behave as if this was the only equation affecting the nature of occupation and discard of stone artefacts.

Although the JSN assemblage has been classified according to a different typology, a preliminary analysis of it reveals that formal types are rarer than at either the Coongie or Cordillo sites. This is consistent with the model. As well, it is further observed that adzes are not present on the site. A possible explanation for this relates to the lack of hardwood trees within the core dunefield region supplying suitable wood for adzing activities. The absence of such trees is very likely related to the availability of water – hardwood specimens being found on the banks of waterholes and lakes.

Comparison Of The Trends In The Assemblages With Data From Other Parts Of The Arid Zone

The trends seen in the assemblages for the region are also echoed in other arid zone work available for comparison. The major study which provides comparative data is that of Veth (1993) for the Western Desert region, Western Australia. His analysis shows similar patterning to that outlined above, with features of assemblages from sites at permanent waters indicating more intensive stone reduction than for either semi-permanent waters or ephemeral water sites. His data show that differences in intensity of reduction are not as clear between semi-permanent and ephemeral water sites as they are between these sites and more permanent ones (see 1993: Tables 8.21–8.31). For a number of features, ephemeral sites show trends characteristic of more intensive reduction than semi-permanent sites, which is not predicted by Veth's model. This appearance of

conflicting trends also appears to be echoed by comparisons between the Cordillo sites and JSN. The sites are more similar to each other than they are to the Coongie sites but there is much variation in the nature and direction of trends between the two groups. This suggests that the permanent sites, in Veth's sample and mine, form clear groups but other sites, while showing some similar trends, are more variable.

The association of higher proportions of formal types in assemblages, especially adzes, with more predictable water sources, is also a trend noted by Veth (1993: 95–96). Veth also found that there was some patterning in the amount of reduction of tula adzes and relation to water sources but that there was a considerable degree of variation (1993: 98–101) and this is also found in my samples.

In his discussion of his results of the artefact analysis, Veth concludes that the timing and intensity of site use are the major factors responsible for variation in the assemblages, rather than distance to raw material sources and the operation of specific discard criteria (1993: 101). This also seems to be the case for the north-east South Australian sites, as I will outline below.

Major Factors Affecting The Patterning Of Sites In The Region

One of the predictions of my model of site patterning is that apart from water sources, availability of stone sources is be one of the most important factors responsible for trends seen and that Aboriginal occupants favoured raw material sources closest to the site.

An examination of the JSN assemblage reveals that the people who visited the site did not behave in this manner. Rather than using the closest stone to the site (40–50 km to the east) for artefact manufacture and discard, the sourcing of stone artefacts from the site indicates that they instead used stone from Della-Dullingari which lies 115 km away, to the north-east (Smith, Williams and Wasson 1991: 185). Despite the use of such distant material, the assemblage does not have features characteristic of extreme reduction (Smith, Williams and Wasson 1991: 185–189). Cores have not been noticeably curated and have not been recycled as other implements. Mean weight of artefacts is significantly greater than for the Coongie sites, despite the fact that utilised stone sources are considerably further away than for the Coongie. Flaked pieces contain much higher proportions of cortex, also consistent with less intense reduction.

The patterning of the JSN assemblage is characteristic of a situation where raw material is closer rather than further away. Yet the paradox can be resolved if we instead see stone source utilisation in terms of re-supply time rather than just in terms of linear distance of stone source from occupation site. For example, if people stopped at JSN as part of a journey to the Della-Dullingari region, they would have been aware that they were only a couple of days away from being able to replenish stone sources. As well, it is likely that the duration of visits to the JSN were relatively short, so that the demand for stone was easily met by the stock-in-hand without recourse to the recycling and the extreme reduction of stone evident at the Coongie sites (Smith, Williams and Wasson 1991: 188).

The JSN site shows that it is not necessarily linear distance from the closest stone sources that is a major factor in the patterning of stone artefact manufacture and discard. The key factors are instead the length of time spent at the site, which in turn relates to the length of time before the group could replenish stone sources.

This line of reasoning can be applied to the Coongie sites as well. The extreme reduction of stone reflected by the assemblages can be seen as the archaeological correlate of residential stability within the lake system relative to other environments in the region. It appears that people chose to stay closer to the lakes even if it meant that they were restricting their access to stone, thus triggering what appears to have been significant pressure on the way they used the resource. This is despite the fact that they could have chosen to be more mobile, travelling more often between stone sources and the lakes. In this latter case, features of such extreme reduction would not be visible in assemblages.

Therefore, like Veth for the Western Desert region, I see the main determinant of site patterning in the Coongie and surrounding areas as relating to the timing and intensity of site use rather than to distance from raw material as such.

This indication of relative residential stability in the Coongie, combined with the high population densities observed in the area at the time of contact implies that the system may have been vulnerable to significant stress given the extreme environmental fluctuations characteristic of the region. It is likely that the system worked

smoothly when resources were abundant but in cases when an anticipated flow of fresh water failed to come down the Cooper or when there was widespread drought, it is possible there were major problems. The fact that the current situation where the Coongie captures most, if not all of the Cooper flow, is potentially very unstable and channel flow could be completely switched on and off as a result of only slight environmental shifts, would exacerbate this.

Ethnographic observations support the notion that stresses were operating on the system. The rigid sanctions outlined earlier involving the enforcement of group boundaries and access to resources indicate this, along with the information that many people in what is now the north-east South Australian region perished during droughts. Further, Wasson's observation of a dune mobilisation event in the late Holocene that might be linked to the intensity of the occupation of the region, is another feature that suggests the system might have been under some stress.

Evidence for 'intensification'?

It is tempting to suggest that the characteristics of the mid-late Holocene occupation of the region reflect an intensive settlement pattern and are derived from a process of 'intensification' (see also Williams 1988: 61). For example, all of the dates for occupation sites for the Coongie system fall within the late Holocene and on all sites recorded within the region, including JSN, the typology of artefacts suggests a mid-late Holocene date. While it is tempting to conclude the region does provide evidence consistent with the operation of such a process, as in my 1988 paper I am cautious about maintaining that these features provide definite evidence. I take this position because it is likely that the environmental instability could be causing major biases in the archaeological record. Such instability could be selectively removing older sites from the archaeological record, or rendering them archaeologically invisible through sedimentation, or even resulting in vast fluctuations in channel flow thus affecting the filling of lakes. I therefore conclude that while the evidence for intensification is persuasive, further geomorphological work is needed to more fully expand on factors affecting the visibility of archaeological material.

Given these issues, can any conclusions can be drawn about the occupation of the arid zone, especially that of the more distant past?

Early Occupation Of The Arid Zone

I will conclude the paper with some brief and speculative comments about models relating to when the arid zone was first occupied on a consistent basis.

As noted in Smith, Williams and Wasson (1991: 190) the evidence from the JSN site indicates regular use of the dunefield region during the late Pleistocene, when there was probably also occupation of the riverine corridors. The presence of *Velesunio* shell at JSN in a Pleistocene context is tangible evidence of some link with these riverine habitats. The nature of the archaeological material present on the site suggests that late Pleistocene use did not involve much on-site stone working and that this changed some time during the mid-late Holocene when visits to the area appear to have become more prolonged and to have involved the grinding of seeds and the manufacture and maintenance of chipped stone artefacts (*ibid*).

Dating of hearths to the period around 12 000 BP for hearths on the lower reaches of Coopers Creek (Veth, Hamm and Lampert 1990) is also consistent with late Pleistocene occupation of what is now north-east South Australia.

Despite the presence of the dunefield site of JSN, Veth (1993) has developed a model suggesting that the continent's core arid zones were only colonised as recently as 5 000 years ago. Veth maintains that the evidence for Pleistocene occupation of JSN does not disprove his model since the Strzelecki dunefield region is located within an area of co-ordinated drainage, thus implying that it was not part of the core arid zone (1993: 111).

Veth's model is an interesting one, but it could prove difficult to test. His 'core arid zones' comprise the deserts of the Great Sandy Desert, Great Victoria and Simpson Deserts. These regions are by definition sandy deserts and are thus areas where outcrops of hard rock are rare and therefore rock shelters with potential Pleistocene sediments are either non-existent or uncommon. Rockshelters such as those examined by Veth (1993) in the Gibson Desert, have late Holocene occupation resting directly on bedrock and thus do not provide contexts for the examination of occupation (or the lack of it) for the period before the late Holocene.

The fact that the presence of rockshelter sites which preserve Pleistocene sediments is so crucial for the examination of whether Pleistocene occupation took place or not, is shown by Veth's

discussion of his model (1993: Chapter 9). All of the eleven Pleistocene sites and early Holocene sites which lie a considerable distance from co-ordinated drainage, and thus form the basis of his model, are rockshelters.

Knowing that rockshelter sites which preserve Pleistocene sediments are likely to be extremely rare in the regions important for Veth's model, it is also unlikely that Pleistocene open sites will be easy to locate. Extensive outcrops of hard rock are not common in the sandy deserts and thus stone suitable for the manufacture of artefacts is also a scarce commodity. It is therefore likely that stone artefact manufacture, one of the major archaeological indicators of human occupation, has to take place on a relatively intensive basis before it becomes archaeologically visible in these regions. The JSN site for example indicates that Pleistocene occupation is not as archaeologically visible as regards stone artefact discard as is mid-late Holocene occupation. This evidence is complemented by my findings for the study area that artefacts do not appear to be present within visible Pleistocene contexts. This is despite that fact that we know from the evidence of JSN that people were using the region during the late Pleistocene.

Further, the logistical difficulties of carrying out systematic archaeological surveys for sites in remote locations such as sandy deserts, compound these problems. JSN was not found as the result of systematic archaeological sampling but was instead located virtually by accident during the course of a geomorphological study of the dunefield by Wasson.

The question of when the core arid zones were first occupied on a systematic basis thus remains a challenging one. Until this question is resolved, JSN remains the continent's sole example of a Pleistocene site located within the midst of the continental dunefield, albeit a dunefield in the vicinity of co-ordinated drainage. The spur to the finding of Pleistocene sites within Veth's 'core arid zones' will be to expand further on the nature of the continent's Pleistocene occupation and to also determine the antecedents of the patterning seen in the mid-late Holocene.

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References

BURKE, R. O. & WILLS, W. J. 1861. 'The Burke and Wills Exploring Expedition'. Wilson & Mackinnon: Melbourne.

CALLEN, R. A. and BRADFORD, J. 1992. The Cooper Creek fan and Strzelecki Creek – hypsometric data, Holocene sedimentation and implications for human activity. *Mines and Energy Review, South Australia* **158**: 52–57.

HISCOCK, P. 1981. Raw material rationing as an explanation of assemblage differences: a case study of Lawn Hill, north-western Queensland. Pp. 178–190 *in* 'Archaeology at ANZAAS, Canberra'. Second printing. Ed. G K Ward. Canberra Archaeological Society: Canberra.

HUGHES, P. J. & LAMPERT, R. J. 1980. Pleistocene occupation of the arid zone of south-east Australia: research prospects for the Cooper Creek-Strzelecki Desert region. *Australian Archaeology* **10**: 52–67.

JONES, W. 1979. 'Up the creek: hunter-gatherers in the Cooper Basin.' B.A. (Hons) thesis, University of New England: Armidale.

KERWIN, B. & BREEN, J. G. 1981. The land of stone chips. *Oceania* **51**: 236–311.

KREIG, G. W. & CALLEN, R A. 1990. Coongie Lakes Control Zone – a map and note for the surface geology and terrain. *Mines and Energy Review, South Australia* **157**: 59–61.

LAYTON, R, FOLEY, R, & WILLIAMS, E. 1991. The transition between hunting-and-gathering and specialized husbandry of resources. *Current Anthropology* **32**: 255–274.

MCBRYDE, I. 1987. Goods from another country: exchange networks and the people of the Lake Eyre Basin. Pp. 252–273 *in* 'Australians to 1788'. Ed. D. J. Mulvaney & J. P. White. Fairfax, Syme and Weldon Associates: Sydney.

MCKINLAY, J. 1862. 'McKinlay's Journal of Exploration in the Interior of Australia'. F. Balliere: Melbourne.

MACUMBER, P J. 1980. The influence of groundwater discharge on the Mallee landscape. Pp. 67–84 *in* 'Aeolian Landscapes in the Semi-arid Zone of South-eastern Australia. Eds. R. R. Storrier & M E Stannard. Australian Society of Soil Science: Wagga Wagga.

MEEHAN, B. 1982. 'Shellbed to Shell Midden'. Australian Institute of Aboriginal and Torres Strait Islander Studies: Canberra.

REID, J. R. W. & GILLEN, J. 1988. The Coongie Lakes Study. Unpublished consultancy report to the South Australian Department of Environment and Planning: Adelaide.

REID, J. R. W. & J. T. PUCKERIDGE. 1990. Coongie Lakes. Pp. 119–131 *in* 'Natural history of the north-east deserts'. Ed. M. J. Tyler, C .R. Twidale, M. Davies and Wells, C. B. *Royal Society of South Australia Occasional Publications* **5.** Royal Society of South Australia: Adelaide.

REUTHER, J. G. 1981. 'The Diari'. Volumes 1–13. Translated by the Reverend P. A. Scherer. Australian Institute of Aboriginal and Torres Strait Islander Studies, Canberra.

SMITH, M. A. 1986. The antiquity of seed-grinding in Central Australia. *Archaeology in Oceania* **21**: 29–39.

SMITH, M. A., WILLIAMS, E, & WASSON, R. J. 1991. The archaeology of the JSN site: some implications for the dynamics of human occupation in the Strzelecki desert during the late Pleistocene. *Records of the South Australian Museum* **25**: 175–192.

TWIDALE, C. R. 1972. Landform development in the Lake Eyre region, Australia. *The Geographical Review* **62**: 40–70.

VETH, P. M. 1993. Islands in the Interior: the dynamics of prehistoric adaptations within the arid zone of Australia. *International Monographs in Prehistory. Archaeological Series 3*

VETH, P. M, HAMM, G. & LAMPERT, R. J. 1990. The archaeological significance of the Lower Cooper Creek. *Records of the South Australian Museum* **24:** 43–66.

WASSON, R J. 1986. Geomorphology and Quaternary history of the Australian continental dunefields. Pp. 419–432 *in* J. C. Vogel, Ed. 'Late Cainozoic Palaeoclimates of the Southern Hemisphere'. A. A. Balkema: Rotterdam.

WILLIAMS, E. 1988. The archaeology of the Cooper Basin: report on fieldwork. *Records of the South Australian Museum* **22**: 53–62.

REVISION OF AUSTRALIAN *AMPHIOPS* ERICHSON, *ALLOCOTOCERUS* KRAATZ AND *REGIMBARTIA* ZAITZEV (COLEOPTERA: HYDROPHILIDAE)

C. H. S. WATTS

WATTS, C. H. S. 1998. Revision of Australian *Amphiops* Erichson, *Allocotocerus* Kraatz and *Regimbartia* Zaitzev (Coleoptera: Hydrophilidae). *Records of the South Australian Museum* **30**(2): 93–106.

The Australian members of the Hydrophilid genera *Amphiops* (five species), *Allocotocerus* (three species) and *Regimbartia* (one species) are revised and redescribed. Keys to species of *Amphiops* and *Allocotocerus* are given. *Amphiops austrinus*, *Amphiops micropunctatus* and *Allocotocerus yalumbaboothbyi* are described as new.

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The three genera included in this revision are grouped for convenience not phylogeny although both *Allocotocerus* Kraatz, 1883 and *Regimbartia* Zaitzev, 1908 belong in the same tribe (Berosini) and they and *Amphiops* Erichson, 1843 are frequently mixed together in collections. All are wet-tropical beetles with, at the generic level, a wide distribution outside Australia (Hansen 1991). They are all relatively small very deep-bodied insects with *Amphiops* and *Allocotocerus* having almost spherical bodies. They occur commonly in pools and swamps around the tropical coast from the Kimberley to about Sydney.

The most recent taxonomic work on the Australian species was by J. Balfour-Browne who briefly commented on them and described *Allocotocerus tibialis* and *Amphiops queenslandicus* (Balfour-Browne 1939) and Hansen, 1991 who discussed their generic placement.

Material was examined from the following collections.

AM	Australian Museum, Sydney
ANIC	Australian National Insect Collection
BM(NH)	Natural History Museum, London
NMV	Museum of Victoria
NTM	Northern Territory Museum
QDPIM	Queensland Department of Primary Industries, Mareeba
QM	Queensland Museum, Brisbane
SAMA	South Australian Museum, Adelaide
UQIC	University of Queensland Insect Collection, Brisbane
WAM	Western Australian Museum, Perth.

Systematics

The three genera can be separated from other Australian aquatic Hydrophilids by the following characters (after Hansen 1991).

Amphiops: Size 2.5–4.5 mm. Dark brown to black. Eyes divided into upper and lower portions by extensions of side of head. Elytra approximately as high as long, without striae. Meso- and meta-tibiae without swimming hairs. First ventrite very short, with a fringe of fine setae rising from its basal margin.

Allocotocerus: Size 3.5–4.5 mm. Black. Meso- and meta-tibiae with swimming hairs. Eyes normal. Elytra as high as long, virtually without striae.

Regimbartia: Size 3.5–5.0 mm. Black. Meso- and meta-tibiae with swimming hairs. Eyes normal. Elytra high, about 2.8x longer than height, with distinct striae.

For more detailed descriptions and discussion of the affinities of these genera see Hansen, 1991.

Amphiops Erichson, 1843

Australian *Amphiops* are all very similar and are best separated by the male genitalia. Indeed I have found it impossible to reliably separate *A. queenslandicus* J. Balfour-Browne and *A. duplopunctatus* Blackburn by any other means. The best general character is the form of the elytral punctation, in particular the interstrial punctation on the sides of the elytra. There are three more or less distinct size classes of elytral interstrial punctures: 1) large, about the size of the strial punctures; 2) small, between about 20–

60% of the larger ones; 3) micro, which are normally no more than pin pricks even under moderate magnification.

Key to Australian Amphiops

1 — Interstrial punctures consisting of a few large punctures and a few to numerous micro punctures, the small size seemingly absent (Figs 1&3). Systematic punctures on pronotum large and distinct 2

— Interstrial punctures consisting of large, small and micro punctures with small predominating (Figs 2 & 4). 3

2 — Central lobe of aedeagus not hooked (Fig. 13). First elytral stria (close to suture) distinct, traceable (anteriorly) well beyond apex of scutellum. Scutellum always moderately punctate ..... *A. micropunctatus* sp.nov.

— Central lobe of aedeagus hooked at tip (Fig. 14). First elytral stria virtually absent. Scutellum lacking punctures or weakly punctate with very small punctures ..... *A. australicus* Blackburn.

3 — Central lobe of aedeagus hooked at tip (Fig. 9). Small punctures on sides of elytra relatively small, < 1/4 diameter of adjacent large punctures (Fig. 4). Serial punctures easily traceable at apex ..... *A. austrinus* sp.nov.

— Central lobe of aedeagus rounded, parameres straight. Small punctures on sides of elytra relatively large, many 1/2 size of adjacent punctures (Fig. 2). Serial punctures may be hard to trace at apex 4

4 — Basal portion of aedeagus shorter than parameres (Fig. 10). Size <3.9 mm. Elytra often with a vague series of darker patches in alternate interstriae ..... *A. duplopunctatus* Blackburn

— Basal portion of aedeagus nearly twice length of parameres (Fig. 11). Size ≥ 3.5 mm. Elytra without series of dark patches. ..... *A. queenslandicus* J. Balfour-Browne.

Amphiops austrinus sp. nov.

Description (number examined 5) Figs 4, 9

Length 3.4–4.0 mm. Broadly oval, elytra deep, almost as high as long. Reddish-brown, disk of pronotum a little darker as are serial punctures. Head broad, strongly punctate with variously sized punctures, confluent at front. Pronotum broad, punctures of various sizes, weak on disk grading to strong laterally, systematic series distinct. Elytron very weakly punctured near suture, grading to strong laterally; in middle at side serial punctures strong, large, somewhat difficult to trace; large punctures separated by own diameter or a bit less, small punctures, which alternate with larger ones, are very much smaller; interstrial punctures of three distinct sizes, largest as large or larger than those in serial lines, separated by own width or less, small punctures more numerous, very much smaller, 1/4–1/3 diameter of large ones, in places third size group of minute (micro) punctures present.

Aedeagus squat, basal portion shorter than parameres. Apical portion of central lobe narrow, weakly tapering, considerably shorter than parameres, ending in small broad hook. Parameres broad in basal half, narrow in apical, strongly curved downwards near tip, tips truncated and a little enlarged.

Distribution

Only known for the type localities in south-east Queensland.

Types

Holotype: 'Brisbane 1/64, CW', SAMA.

Paratypes: 4, 'Qld Petrie, 10 km W, 23/11/95, C. Watts', SAMA.

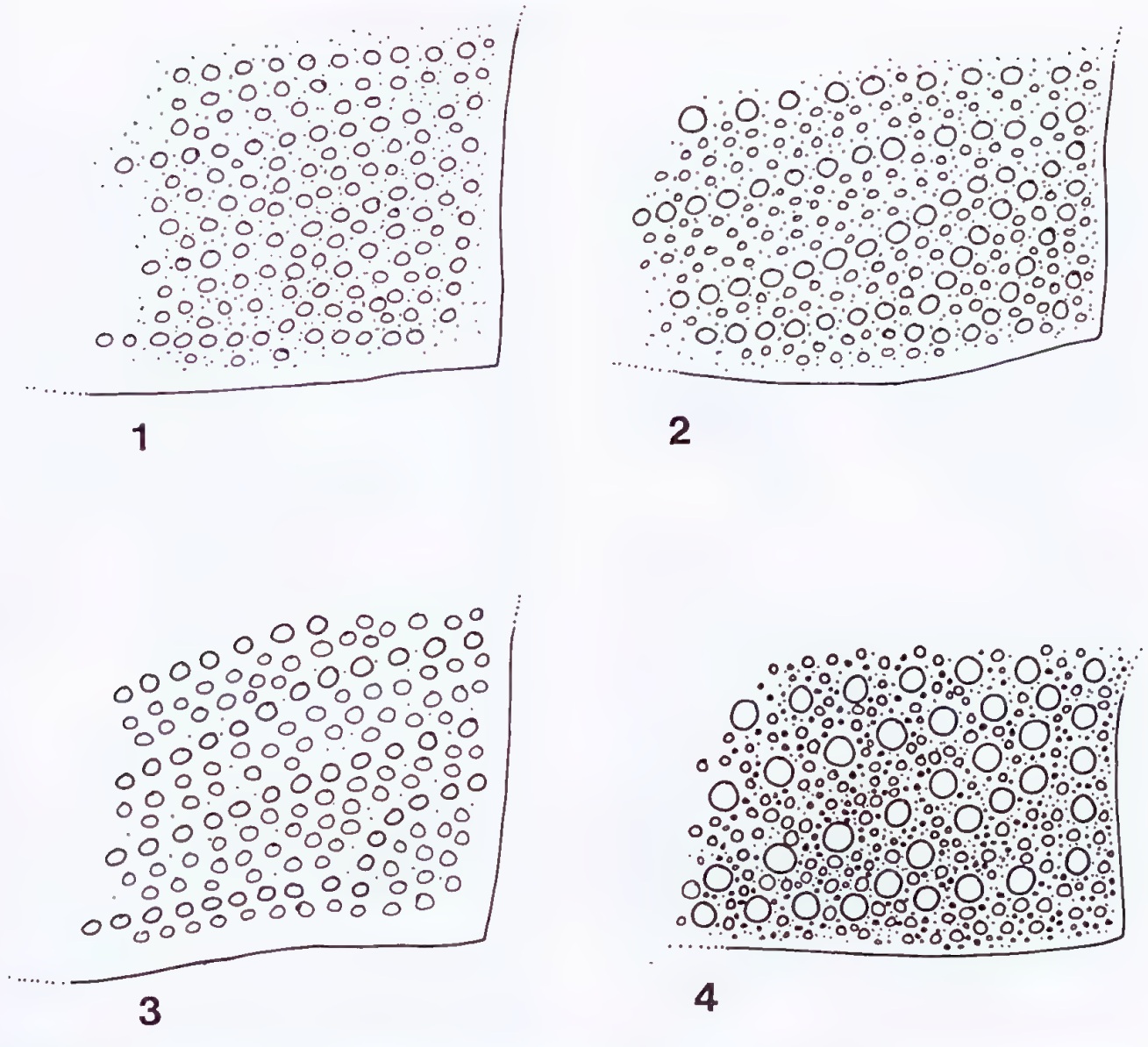
Remarks

In most characters similar to *A. duplopunctatus* and *A. queenslandicus*. Apart from the male genitalia *A. austrinus* differs from both of these by the greater contrast in size between the large and small interstrial punctures on elytra, caused primarily by the comparatively small size of the small punctures. In *A. duplopunctatus* and *A. queenslandicus* the small interstrial punctures become quite prominent towards the side and apex, often reaching half the size of the larger ones. In *A. austrinus*, apart from very near the elytron edge, the small punctures remain much smaller than the larger ones. The downward curve of the parameres and the apical hook on the tip of the central lobe of the aedeagus, also clearly set it apart from these two species.

Amphiops australicus Blackburn, 1898

Description (number examined 234) Figs 3, 14

Length 2.7–4.0 mm. Broadly oval, elytra deep, about as high as long. Brown, sometimes with distinct darker blotches on elytron, to black with



FIGURES 1–4. Pattern of punctures near anterior-lateral angle of elytron. **1**, *Amphiops micropunctatus;* **2**, *Amphiops duplopunctatus;* **3**, *Amphiops australicus;* **4**, *Amphiops austrinus.*

some vague lighter areas. Head broad, moderately to strongly punctate, punctures mainly small with scattered much larger ones, becoming stronger and denser in front, confluent and rugose along front margin. Pronotum broad, weakly punctured, punctures almost obsolete on disk but becoming stronger laterally, much smaller than eye facet, systematic punctures small, about size of eye facet. Elytra weakly punctured on disk, becoming stronger laterally. At side in middle, serial punctures about puncture-width apart, lacking alternating small punctures. Interstrial area usually only with large punctures which are approximately same size, and approximately same size as serial punctures, about a puncture-width apart or somewhat greater. Areas of elytra near the scutellum and laterally may have indistinct micro punctures.

Aedeagus elongate, basal piece about same length as parameres. Central lobe narrow, narrowing to point, tip with upward hook, shorter than parameres. Parameres elongate, broad in basal half, narrow in apical, tips weakly expanded, curved downwards in apical fifth.

Type

Holotype female: '5074T', 'Adelaide R, NW Australia, J. J. Walker', 'Blackburn Coll 1910–236', 'Amphiops australicus, Blackburn', with round type label, BM(NH). Seen.

Distribution

Northern Territory

11 km SW by S Borroloola, ANIC; Cahills Crossing, ANIC; 7 km NW by N of Cahills Crossing, ANIC; Gimbar Stn, NTM; Howard Springs, SAMA; Holmes Jungle, NTM; Jabiru, NTM; Junction of Arnhem Hwy and Oenpelli Rd, NTM; Kakadu NP, NTM; Koongarra, ANIC; Magela Ck, ANIC; McArthur R, ANIC; 19 km E by S of Mt Borradaile, ANIC; 30 km WSW Mt Cahill, ANIC; 9 km N of E Mudginbarry HS, ANIC; Nourlangie Ck, ANIC; 18 km E by N Oenpelli, ANIC; Tindale, ANIC, NMV; UDP Falls, NTM; 12°40S 132°54E, ANIC; 12°06S 133°04E, ANIC.

Queensland

12°08S 142°16E, ANIC; 12°22S 142°37E; 12°06S 142°33E, ANIC; 14°51S 142°58E, ANIC; 18°33S 138°11E, ANIC; Archer Bend, SAMA; Batavia Downs HS, ANIC; Barron Falls, ANIC; Bertiehaugh Ck, ANIC; Cairns, ANIC; 110 km S Coen, NMV; East Claudie R, UQIC; 110km S Coen, NMV; 70 km SW Greenvale, SAMA; Hann R, ANIC; Lakefield NP, QDPIM; 50M N. Laura, UQIC; 72 km NW Laura, ANIC; 21 km E Mareeba, QDPIM; Moreton, ANIC; 2 km NNE Mt Tozer, ANIC; 9 km ENE Mt Tozer, ANIC; 3 km NE Mt Webb, ANIC; 10 km WNW Rokeby, ANIC; Wenlock R, ANIC.

Western Australia

14°25S 126°40E, ANIC; 14°52S 125°50E, ANIC; 14°52S 125°50E, ANIC.

Remarks

Among Australian *Amphiops, A. australicus* can only be confused with *A. micropunctatus* due to the virtual lack of small and micro punctures on the elytra. *Amphiops micropunctatus* has more extensive micro punctures over the elytra but these can be missed if the specimen is at all dirty or the light poor. The two species are best separated by the much more strongly punctate scutellum and the quite well developed first elytral stria on *A. micropunctatus,* compared to the virtually impunctate scutellum region in *A. australicus.* I have not seen any black specimens of *A. micropunctatus* but light coloured *A. australicus* are occasionally encountered, usually with well marked dark patches on elytra. The tip of the aedeagus in *A. australicus* is hooked, in *A. micropunctatus* it is not.

Amphiops duplopunctatus Blackburn, 1898

Description (number examined 65) Figs 2,10

Length 3.0–3.9 mm. Broadly oval, elytra deep, as high as long. Dark reddish-brown, elytra with vague lighter patches. Head broad, strongly punctate, punctures of varying size, often becoming confluent along front margins. Pronotum broad, weakly punctured on disc, becoming stronger laterally, punctures of various sizes, systematic series moderately distinct, relatively small, about same size or a little larger than eye facets. Elytra weakly and shallowly punctured on disc, becoming much stronger towards sides. At side, in middle, serial punctures large, easy to trace, each separated by own width or less, alternating with a small puncture. Interstrial punctures of three sizes, largest a bit smaller than serial punctures and most separated by more than their width, small punctures much more numerous and 1/3–1/2 diameter of large ones, numerous and relatively large micro punctures.

Aedeagus with basal piece shorter than parameres, apical portion of central lobe narrowing to thin point, lacking any apical thickening or hook, shorter than parameres. Parameres wide in basal half, narrow in apical half, tips rounded not curved.

Types

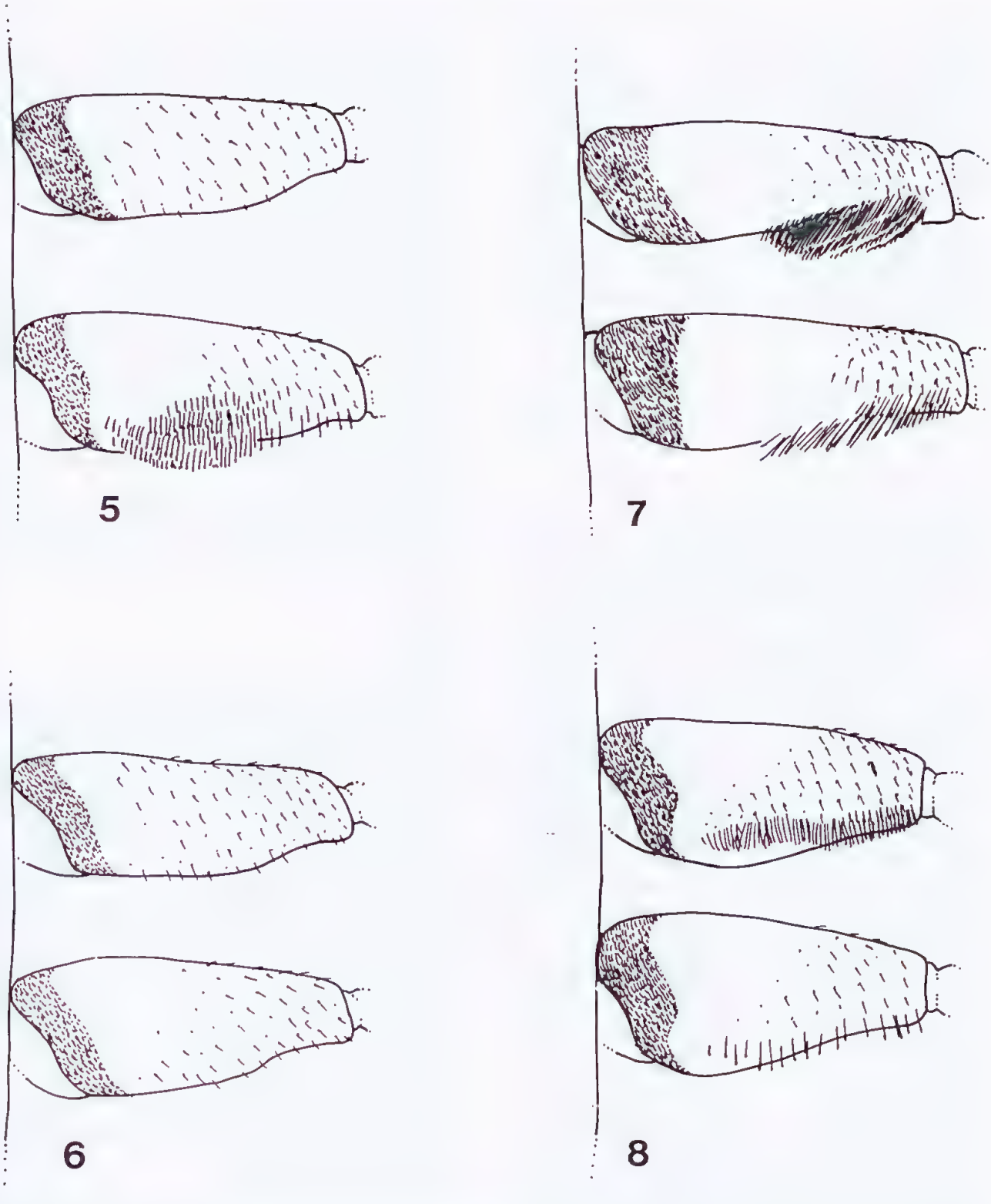
Holotype female: '6370 Qu. T.', 'Blackburn Coll 1910–236', 'Amphiops duplopunctatus, Blackburn', BM(NH). Seen.

Lectotype: 'Queensland Blackburn's Coll.', 'Amphiops duplopunctatus BL. co-type', dissected and remounted, SAMA. Seen.

Distribution

Northern Territory

Daly R Crossing, NTM, ANIC; Darwin, ANIC, NTM, SAMA; 11km NE of E of Darwin, ANIC; Gimbat Stn, NTM; Holmes Jungle, ANIC, NTM, SAMA; Howard River, NTM; Howard Springs, NTM, SAMA; Humpty Doo, NTM, QDPIM; 10 km N of Jabiru, NTM, QDPIM; 29 km W by N Jabiru, NTM, ANIC; Keep River NP, NTM, ANIC; Magela Ck, ANIC; 12 km NNW Mt Cahill, NTM, ANIC; 19km WSW Mt Cahill, ANIC; 9km N by E of Mudginbarry, ANIC; Nabarlek Dam, ANIC; 6km SW by S Oenpelli, ANIC; Sth Alligator R, ANIC; 15 km SE Wangi, NTM; Yungaburra, NTM, QDPIM; 16°02S 130°23E, NTM.



FIGURES 5–8. Ventral view of mesofemur (top) and metafemur (bottom). **5**, Male *Allocotocerus yalumbaboothbyi;* **6**, Female *Allocotocerus yalumbaboothbyi;* **7**, Male *Allocotocerus tibialis;* **8**, Female *Allocotocerus tibialis.*

Queensland

Bamaga, SAMA, UQIC; Barringtonia Lagoon W Cape York, QM; Batavia Downs HS, ANIC; Bertihaugh Ck, ANIC; 8 km N Bluewater, SAMA; 9km N Bluewater, SAMA; Burster Ck, ANIC; Caloundra, SAMA; Claudie R, UQIC; Dalhousie R, ANIC; East Claudie R, UQIC; Flinders Is, SAMA; 12 km SW Heathlands, ANIC; Holroyd R, ANIC; Iron Range, UQIC; Jordine R, UQIC; Kuranda, SAMA; Lawn Hill,

ANIC; Lake Barrine, ANIC; Lake Tinaroo, ANIC; 73km NW of W Laura, ANIC; Lockerbie, UQIC; 9 km NNW Lockhart R, ANIC; 18 km N Mareeba, QDPIM; Mazlin Ck, QDPIM, ANIC; 3 km ENE Mt Tozer, ANIC; 9 km ENE Mt Tozer, ANIC; 11 km ENE Mt Tozer, ANIC; Murphy's Ck, UQIC; Normanby R, ANIC; Pascoe R, ANIC; N Pine River, QM; Redcliffe, UQIC; Ripley, SAMA; 27km NW by W Rokeby, ANIC; Schramm Ck, ANIC; Townsville, SAMA, 20km S Townsville, SAMA; 3 km WSW Ussher Point, ANIC; Wenlock R crossing, ANIC; 18°35S 138°03E, ANIC; 18°40S 138°20E, ANIC.

Western Australia

Carson Escarpment, ANIC; Drysdale R, ANIC;

Remarks

If reference material is available *A. duplopunctatus* can be relatively easily separated from *A. austrinus* by its stronger interstrial punctation, but lacking reference specimens it can only be separated with certainty from this species by its aedeagus.

Typical *A. duplopunctatus* are smaller, higher and often darker than *A. queenslandicus* and have stronger large punctures on elytra. In many *A. duplopunctatus,* particularly from the Northern Territory, many of the large serial punctures on the sides of the elytra are less than a puncture-width apart, a condition I have not seen in any *A. queenslandicus*. Except for particularly dark specimens, *A. duplopunctatus* usually has quite regular darker blotches in alternate elytral interstriae variably distinct. *Amphiops queenslandicus* lacks these and has more uniformly coloured elytra although the punctures are often darker particularly laterally. *Amphiops duplopunctatus* is also smaller than *A. queenslandicus* (<3.9 mm as compared to >3.5 mm).

Balfour-Browne (1939), considered *A. duplopunctatus* to be possibly no more than a subspecies of *A. australicus*, an opinion based mainly on a perceived close similarity of the male genitalia. The male genitalia of what I take to be *A. australicus* and *A. duplopunctatus* are clearly distinct (the types are female). The markedly different punctation also differentiates the two species.

Amphiops micropunctatus n. sp.

Description (number examined 30) Figs 1, 13

Length 2.7–4.3 mm. Oval, elytron deep, a little longer than high. Reddish-brown, punctures on elytron darker. Head broad, moderately strongly punctate, punctures tending to be either big or small, smaller predominating, becoming confluent on front margin. Pronotum broad, moderately punctate, punctures of varying sizes, stronger laterally, systematic series distinct, comparatively large, many over twice size of adjacent punctures, nearly twice size of eye facet. Elytra weakly and shallowly punctured on disc, becoming much stronger towards sides. Laterally in middle serial punctures large, easy to trace, about a puncture-width apart; interstrial area shiny, punctures of two sizes, the larger sparse, most > 2x width apart, somewhat smaller than strial, the smaller, more numerous, very small (micro), in contrast to other punctures, becoming obsolete laterally.

Aedeagus with basal piece about same length as parameres, parameres wide in basal half, narrow in apical, tips broadly rounded, central lobe narrow, tip bluntly pointed, reaching nearly to end of parameres.

Remarks

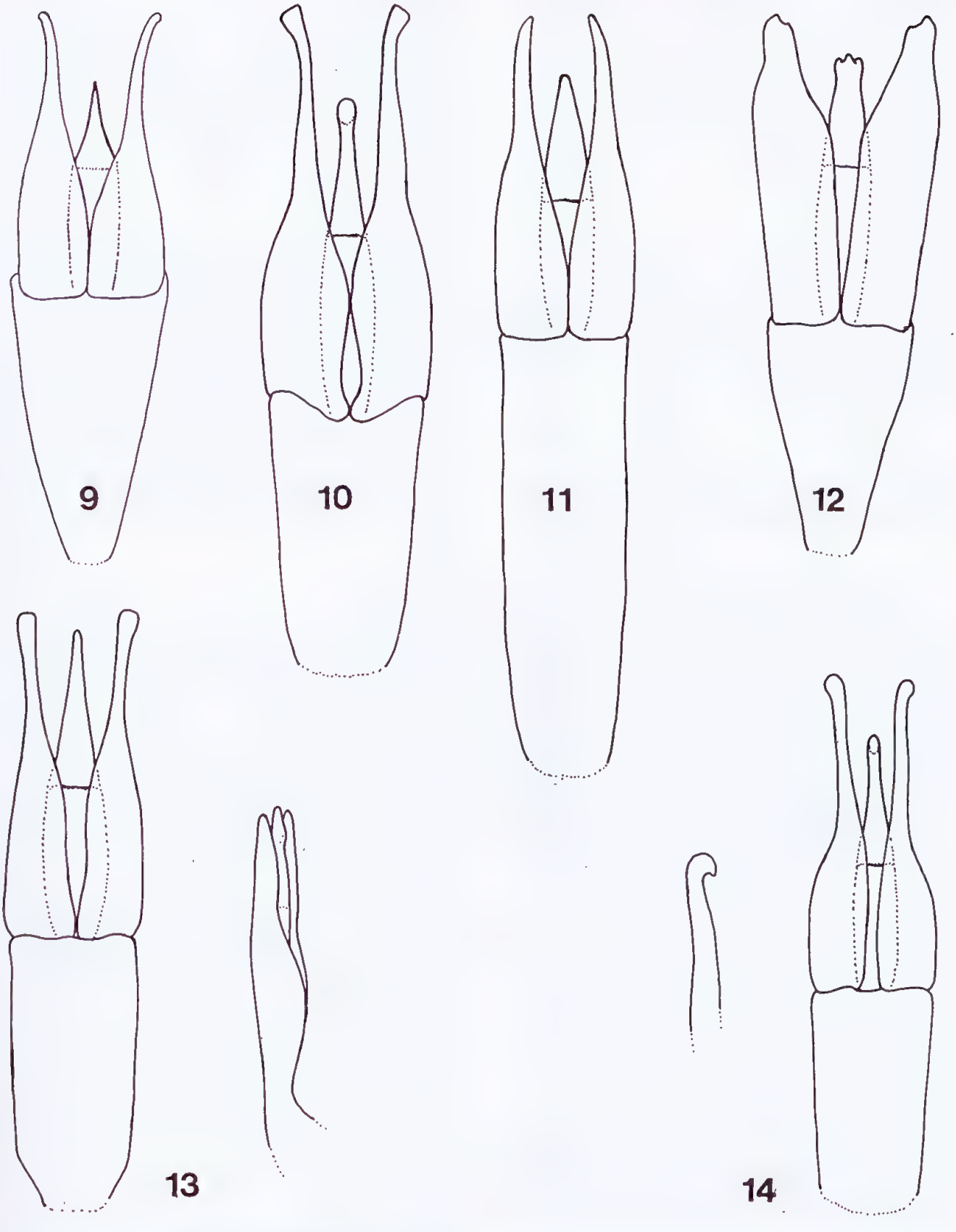
In colour and size resembling *A. duplopunctatus* but differing from it in punctation and in the shape of the aedeagus which has the central lobe larger than in *A. duplopunctatus*. The absence of the 'small' size of interstrial punctures in the species resembles *A. australicus* and readily separates these two species from the other Australian *Amphiops* which have the interstrial areas much more punctate. From *A. australicus* (and most other Australian *Amphiops*) it differs by having the first (sutural) elytral stria quite well developed as well as a greater development of very small (micro) punctures on the elytra, although an occasional *A. australicus* may have quite extensive micro punctation.

This species is only known from a limited area of North Queensland. Judging from the localities it is possible that it is a closed forest species. The specimens from the West Claudie basin and Lockhart River were taken in October from still pools in closed forest. No other habitat information is available.

Types

Holotype male: 'Australia, N Qld 15 km WNW of South Johnstone "Light Trap"', 'Fay and Halfpapp 1986', QDPIM.

Paratypes: 2 same data as holotype, QDPIM; 1, 'Australia N Qld Tolga 3', '1986 J. D. Brown light Trap', QDPIM; 1, 'Cow Bay, N of Daintree



FIGURES 9–14. Ventral view of aedeagus. **9**, *Amphiops austrinus*; **10**, *A. duplopunctatus;* **11**, *A. queenslandicus*; **12**, *Regimbartia attenuata*; **13**, *Amphiops micropunctatus*; **14**, *A. australicus.*

N Qld, 15–22nd March 1984 I. C. Cunningham', QDPIM; 2, '12°43S 143°17E, 9 km ENE of Mt Tozer 5–10th July 1986 T Weir and A. Calder', ANIC; 3, '12.44S 143.14E 3 km ENE of Mt Tozer 28th Jun – 4th July 1986 T Weir and A. Calder', ANIC; 10, '15°03S 145°09E 3 km NE Mt Webb 30th April – 3rd May 1981 A Calder', 8 ANIC, 2 SAMA.

Distribution

Queensland

Dead Horse Ck, ANIC; East Claudie R, UQIC; Gordon Ck nr Claudie R, UQIC; Iron Range, UQIC; 9km NNW Lockhart R, ANIC; 3.5km SW by S Mt Baird, ANIC; 2km NNE of Mt Tozer, ANIC; 6km ENE Mt Tozer, ANIC; 11km ENE Mt Tozer, ANIC; Mt Webb Nat. Pk, ANIC; West Claudie R, ANIC.

Amphiops queenslandicus Balfour-Browne, 1939

Description (number examined 34) Fig. 11

Length 3.5–5.3 mm. Broadly oval, elytra deep, almost as high as long. Dark reddish-brown, elytra with vague darker/lighter areas and many serial punctures black. Head broad, strongly punctate, punctures of varying sizes becoming confluent along front margin. Pronotum broad, moderately punctate on disc becoming stronger toward sides, systematic punctures moderate, about 3x size of adjacent punctures, a little larger than eye facet. Elytra with small but sharp punctures on disc becoming much stronger laterally. At sides in middle, large serial punctures relatively small, most separated by more than their widths, small alternating punctures relatively large, some approaching 1/2 width of larger ones; interstrial punctures of three sizes: large, larger than serial punctures, separated by more than their width, small much more numerous, relatively large, 1/4–1/2 diameter of large ones, micro punctures present over most of elytra.

Aedeagus elongate, basal piece nearly twice length of parameres. Central lobe shorter than parameres, narrowing to a point, apex not swollen or hooked. Parameres broad basally, becoming narrower apically, tips rounded, weakly curved downwards.

Types

Holotype male: 'Queensland Australia', 'Amphiops queenslandicus Type J. Balfour-Browne det.', with round Type label and a handwritten locality (which I cannot read), BM(NH). Seen.

Paratypes: 6, same data as Holotype (except handwritten label and Type designation); 1, male, 'Rockingham austral', 'Australia' Amphiops queenslandicus M. J. Balfour-Browne det., all in BM(NH) with round paratype labels. Seen.

Distribution

Northern Territory

S Alligator R, QM; Black Point Coburg Pen, ANIC; 5km NNW Cahills Crossing, ANIC; 7km NW by N Cahills Crossing, ANIC; Coastal Plains Research Station, ANIC; Daly R Mission, ANIC; Darwin, SAMA; Fogg Dam, NTM; Howard Springs, SAMA; Humpty Doo, ANIC; Jabiru, NTM; Jim Jim, ANIC, NTM; Kakadu NP, NTM; Kapalga, QM; Koongarra, ANIC; 12km NNW Mt Cahill, ANIC; 19km WSW Mt Cahill, ANIC; 9km N by E of Mudginbarry HS, ANIC; Oenpelli, AM; 6km SW by S Oenpelli, ANIC; 12°40S 132°22E, QM.

Queensland

Ashgrove, QM; Ayr UQIC; Bowen, SAMA; Brisbane, UQIC; Bulburin St Forest via Many Peaks, UQIC; Caloundra, SAMA; Cooloola, QM; East Claudie R, UQIC; Gatton, UQIC; Homehill, SAMA; Ingham, UQIC; Ipswich, AM; Iron Range, UQIC; Lockerbie UQIC; Many Peaks, UQIC; S Pine R, QM; Ripley, SAMA; Rockhampton, ANIC, SAMA; 20 km S Townsville, SAMA; 37 km S Townsville, SAMA.

Remarks

The distinctive male genitalia readily identify this species. *Amphiops duplopunctatus* is smaller with the elytra not quite as deep, elytral punctures weaker and usually differently coloured (see under *A. duplopunctatus*).

Amphiops queenslandicus also closely resembles *A. austrinus* but in this case the weaker, smaller punctures on the elytra of *A. austrinus* seem different enough to enable reliable separation. However, the male genitalia should be used wherever possible.

Regimbartia Zaitzev, 1908

Regimbartia attenuata (Fabricius,1801)

= *Volvulus scaphiformis* Fairmaire, 1879. Synonymy after d'Orchymont, 1932.

Description (number examined 89) Fig. 12

Length 3.6–5.0 mm. Narrowly boat-shaped, high, sides of elytra subparallel, perpendicular, black, shiny, appendages testaceous. Head deflexed, eyes large, punctures moderate scattered, weaker on disc, those forward of eye about size of eye facet, systematic punctures inward from eye relatively small, about size of eye facet. Pronotum broad, weakly and sparsely punctured on disc, more strongly towards sides where they are about same size as on front of head; systematic punctures few and hard to trace. Elytra more strongly punctured, somewhat stronger at sides than on disc, each elytron with 10 serial lines, inner two incomplete anteriorly, for the most part serial punctures joined forming sharp grooves. Mesosternum with strong narrow keel, apical sternite with short sharp spine in midline at apex.

Male: Protarsi with two basal segments moderately expanded dorso-ventrally.

Types

Hydrophilus attenuata Fabricius. Ceylon. Type not located.

Volvulus scaphiformis ? Holotype. Rockhampton Fairmaire, ?in Museum Godeffroy. Not seen.

Distribution

Northern Territory

Bessie Springs, ANIC; 11 km SW by S of Borroloola, ANIC; 30 km NE by E of Borroloola, ANIC; 48 km SW by S Borroloola, ANIC; 1 km N of Cahills Crossing, ANIC; 7 km NW by N Cahills Crossing, ANIC; Daly River, NTM; Darwin, ANIC, SAMA; Elsey Creek, ANIC; Fergusson R, ANIC; Fogg Dam, ANIC, NTM; Howard Springs, SAMA; Jabiru, NTM; Katherine, NTM; Keep River NP, ANIC; Lake Bennett, NTM; Magela Ck, ANIC; Manton Reservoir, NTM; 2 km N Mudginberri HS, ANIC; 6 km N by E Mudginberri, ANIC; Nourlangie Ck, ANIC; Roper R, ANIC; South Alligator R, QM; U.D.P. Falls, NTM;

Queensland

Archer Bend, SAMA; Ayr, UQIC; Brisbane, MV, QM, UQIC; Cairns, ANIC, QM; Calliope R, ANIC; Caloundra, SAMA; Cape Flattery, DPIM; Chillagoe, DPIM; Claudie R, UQIC; East Claudie R, QIC; Clermont, AM; Cooktown, MV; 40M N Cooktown, UQIC; Duaringa, AM; Edungalba, ANIC; Einasleigh, DPIM; Frenchman's Creek via Rockhampton, UQIC; Gin Gin, UQIC; Gregory River Hotel, DPIM; Homehill, SAMA; Kirrama Rng, QM; Karumba, UQIC; Lakefield NP, ANIC; Mackay, SAMA; Mareeba, ANIC, DPIM; 18km N Mareeba, DPIM; Mary Ck, ANIC; McIvor R, UQIC; Mt Garnet, SAMA; 3.2 km SW of Mt Inkerman, ANIC; Mt Molloy, ANIC, QM; 3 km ENE Mt Tozer, ANIC; 6 km ENE Mt Tozer, ANIC; Nordello Lagoon, DPIM; 11km WSW Petford, DPIM; N Pine R, QM, UQIC; Rockhampton, SAMA; 67 km E Roma, QM; Samford, UQIC; Silver Plains CP, DPIM; 15km WNW South Johnstone, DPIM; Starbright HS, DPIM; Strathmore Stn, DPIM; Tolga, DPIM; Townsville, QM; Walkamin, DPIM; 40km S Weipa, DPIM; Yaamba, UQIC; Yeppoon, UQIC; 18°38 S 138°11 E, ANIC; 18°34 S 138°08 E, ANIC.

Western Australia

Channley R, ANIC; Derby, SAMA; Fitzroy R, ANIC; 12 km S Kalumburu Mission, ANIC; Kunanurra, DPIM; 1 km NNE Millstream, ANIC; Synnot Ck, ANIC; 14°53 S 125°45 E, SAMA.

New South Wales

Eccleston, UQIC.

Remarks

Once known, this distinctive water beetle is unlikely to be confused with any other Australian species. It is relatively common in shallow swamps and dams along the coast from northern New South Wales to the Kimberley. Beyond Australia the species has a wide distribution in South-east Asia as far west as Sri Lanka.

I have followed d'Orchymont (1932 p. 709) for the name of this widespread species.

Allocotocerus Kraatz, 1883

The three Australian species of *Allocotocerus* (= *Globaria* Latreille) are all moderately sized, highly spherical insects with the ventral surface shiny black. Within Australia they can only be confused with species of *Amphiops*, particularly *A. queenslandicus* which is of a similar size and shape. The even, regular punctation, uniformly black ventral surface, and swimming hairs on the legs in *Allocotocerus* readily separate them from *Amphiops*.

There is little to separate the species other than the sexual characters of the aedeagus, trochanter setae and the labrum.

The first described and best known species, *A. punctatus*, is common and widespread in slowly

moving water and in swamps in eastern Australia from northern New South Wales northwards. It appears to be absent from the Northern Territory and northern Western Australia where its place is taken by *A. tibialis* and *A. yalumbaboothbyi*. Conversely these species likewise have not been recorded from the east coast.

An additional species (the type species, *A. bedeli* Kraatz 1883) occurs in New Guinea. Unfortunately the holotype does not appear to be in the Deutsches Entomologisches Institut in Eberswalde. In its place is a label written by Korschefsky in 1937 indicating it was lost (Lothar Zerche pers. com.). The recognition of this species and any possible influence on the nomenclature of Australian species must await the collection of further specimens from New Guinea.

Key to Australian Allocotocerus

1 — Labrum strongly extended forward, strongly bifid ..... male *A. punctatus* (Blackburn)

— Labrum normal, often hidden beneath clypeus, not bifid 2

2 — Protibia light yellow with darker apical portion ..... *A. punctatus* (Blackburn)

— Protibia lighter than other legs but without darker apical portion 3

3 — Setae on outer posterior angle of ventral surface of mesofemur more developed than those on metafemur (Figs 7 & 8). Aedeagus with parameres broad with rounded tips, central lobe sharply pointed, much shorter than parameres (Fig. 16) ..... *A. tibialis* (Balfour-Browne)

— Setae on metafemur equally poorly or slightly more developed than on mesofemur (Figs 5 & 6). Aedeagus with parameres narrowing to point, central lobe broad with narrow spine at tip, as long as parameres (Fig. 17) ..... *A. yalumbaboothbyi* sp. nov.

Allocotocerus punctatus (Blackburn, 1888)

Description (number examined 112) Fig. 15

Length 3.5–4.5 mm. Oval, elytra high, height only a little less than length. Black, shiny, appendages lighter, yellowish with darker terminal portion to tibia. Head narrow, front margin broadly and quite deeply concave, sides of clypeus narrowly margined, rather evenly covered with moderate punctures which are weaker in middle than at sides, those forward from eyes a bit larger than size of eye facet, systematic punctures virtually absent. Pronotum narrower than elytra, punctures on disc much weaker than on head, becoming considerably stronger towards front corners, systematic punctures few, sparse and hard to find. Elytra covered with very even punctures in same area but much stronger laterally than on disc, serial punctures 1.5–2x diameter of adjacent punctures, reduced to 2–3 short lines midway along side of elytron. Midline of mesosternum with strong, tall spike between mesocoxae. First ventrite constricted in middle with rather wide strong midline carina. Metasternum with two strong carinae in midline with deep gap between them, the anterior one cylindrical and angled backwards, the posterior one anvil shaped in lateral view.

Male: Labrum prominent, front edge deeply bifid. Protibia triangular in cross-section. Aedeagus with basal portion strongly bent, 2.5x length of parameres which are broad for whole length, central lobe broad except for short very narrow portion at apex. Meso- and meta-trochanters with widely scattered short, stout setae on ventral face.

Female: Labrum little exposed, front edge not bifid. Protibia of normal shape, contrast between dark apical portion and yellow on rest of proleg often less pronounced than in male. Meso- and meta-trochanters with scattered, sparse, short, stout setae on ventral face.

Type

Holotype: 'T2328', 'Blackburn coll 1910–236', 'Volutus punctatus, Blackburn', BM(NH). Seen.

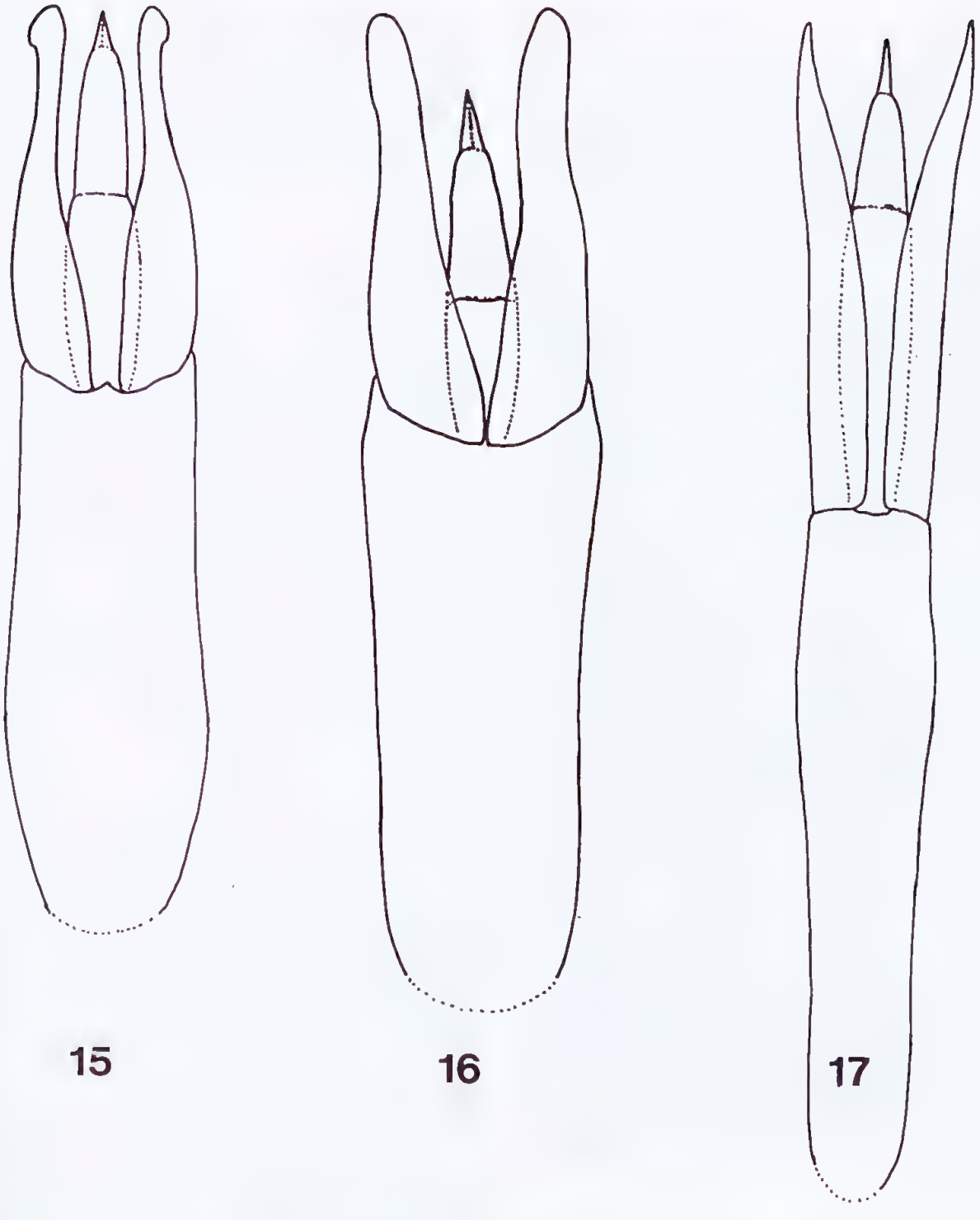
Distribution

Queensland

8 km N Bluewater, SAMA; Cardstone, ANIC; 40 km N Coen, SAMA; 70 km N Coen, SAMA; Caloundra, SAMA; 29 km NW by W Cooktown, ANIC; 40 km N Cooktown, SAMA; Ingham, ANIC; Lakefield NP, QDPIM; 18 km N Mareeba, QDPIM, ANIC; Mary Ck, ANIC; Mc Ivor R, ANIC; Townsville, MV; Moorehead R, ANIC; Moreton, ANIC; Mt Coolum, ANIC; 20 km S Townsville, SAMA; 37 km S Townsville, SAMA; Wenlock R Crossing, ANIC; 15°17S 145°10E, ANIC.

Remarks

In overall shape, punctation and colour closely similar to *A. tibialis* and *A. yalumbaboothbyi* but the male characters readily separate it from these species. Male *A. yalumbaboothbyi* and *A. tibialis*



FIGURES 15–17. Ventral view of aedeagus. **15**, *Allocotocerus punctatus;* **16**, *Allocotocerus tibialis;* **17**, *Allocotocerus yalumbaboothbyi.*

lack the very distinctive labrum and protibia of male *A. punctatus*. In *A. punctatus* the dark apical portion of the protibia separates both male and female from the other species which have more uniformly coloured protibiae. In both male and female *A. tibialis*, the number and density of setae on the trochanters are much larger than in *A. punctatus*.

The species is relatively common in coastal dams and swamps from northern Southern Queensland to Cape York, often found together with the similarly shaped *Amphiops*.

Allocotocerus tibialis (Balfour-Browne, 1939)

Description (number examined 61) Figs 7, 8, 16

Length 4.5–5.0 mm. Oval, elytra high, height

only a little less than length. Black, shiny, appendages dark-testaceous. Head narrow, front edge widely and moderately concave, sides of clypeus margined, strongly punctured, punctures in front of eyes larger than eye facet, systematic punctures inwards from eye few and hard to trace, punctures on disc somewhat weaker than elsewhere, about size of eye facet. Pronotum narrow, somewhat more weakly punctured than head particularly on disc, systematic punctures few and hard to find. Elytron punctured rather more strongly than on pronotum and head, punctures much weaker on disc than on sides where they are strong and less than a puncture-width apart. Serial punctures few or absent, if present little larger than adjacent punctures. Mesosternum with moderately tall, sharp spine in midline. Midline of metasternum with two distinct carinae, separated by deep gap, anterior carina cylindrical and angled strongly backwards, posterior one broader and curving backwards and upwards when viewed from side. First abdominal ventrite narrowed in middle half, midline with rather narrow and strong carina, ventrites two and three narrowed in central half, weakly bulbous/carinate in midline. Area between ventrites deeply grooved. Fourth ventrite weakly narrowed anteriorly, smooth.

Male: Labrum simple. Protibia a little flattened and widened, tarsi unmodified. Mesotrochanters stout with a well-marked group of long golden setae on anterior apical ventral angle, inner half of ventral face lacking punctures/setae. Metatrochanters stout with a less well-developed group of setae in same place, metatibia stout. Aedeagus long, sinuate, relatively broad, basal piece about 1.5x length of parameres, parameres broad, subparallel, rounded at tips, central lobe narrowing progressively to tip, shorter than parameres.

Types

Holotype male: 'Adelaide River 92–2', '4969', 'Globaria tibiale mihi J. Balfour-Browne det.' with red type label, BM(NH). Seen.

Lectotypes: 1, 'Adelaide River, NW Australia J. J. Walker', 'G. C. Champion Coll. B.M. 1927–409' with red (allotype) type label, BM(NH), 10 same data, in BM(NH); 3, same data as holotype, BM(NH). Seen.

Distribution

Northern Territory

Gimbat Stn, NTM; 6 km E Humpty Doo, QDPIM; Jabiru, NTM; 10 km N Jabiru, QDPIM; Junction of Arnhem Hwy and Oenpelli Rd, NTM; Magela Ck, ANIC; 19 km E by S Mt Borradaile, ANIC; 8 km E Mt Cahill, ANIC; 46 km WSW Mt Cahill, SAMA; Nabarlek Dam, ANIC; Nourlangie, ANIC; UDP Falls, NTM; Wildman R, NTM.

Remarks

Both male and female *A. tibialis* can be separated from *A. punctatus* and *A. yalumbaboothbyi* by the more extensive development of setae on the mesotrochanters. The elytral striae are also usually much weaker or absent in this species but at least traceable in the others. The species has not been recorded from the east coast and appears to have a rather restricted distribution in coastal Northern Territory. Here it occurs commonly, often with *A. yalumbaboothbyi*.

Amphiops tibialis can also be separated from the very similar *A. yalumbaboothbyi* by the differently shaped posterior mesosternal protuberance: in *A. tibialis* this is thicker and curved upwards behind in lateral view whereas it is straight in *A. yalumbaboothbyi*.

***Allocotocerus yalumbaboothbyi* sp. nov.**

Description (number examined 51) Figs 5, 6, 17

Length 3.5–4.5 mm. Oval, elytra high, only a little longer than high. Black, shiny, ventral surface and appendages dark-testaceous, proleg yellowish. Head narrow, front margin broadly and quite deeply concave, rather evenly covered with moderate punctures which are a little weaker on disc than at sides, those forward from eyes a bit larger than size of eye facet, systematic punctures virtually absent. Pronotum narrower than elytra, punctures on disc much weaker than on head, becoming considerably stronger towards front corners, systematic punctures few and hard to find. Elytra covered with very even punctures which become much stronger laterally, serial punctures reduced to 2–3 short lines on each elytron towards sides in middle; midline of mesosternum with tall sharp spike forward of mesotrochanters, midline of metasternum with two strongly raised carinae separated by short deep gap, front carina in shape of backwardly inclined broad spine, rear carina oval shaped on a broad pedestal when viewed laterally. First ventrite moderately constricted in middle with a narrow but well marked central carina extending

forward between metatrochanters. Second sternite also constricted but without carina, fourth not restricted. Sutures between ventrites wide, deep, well-marked.

Male: Labrum small, usually contracted, not bifid, protibia not expanded, basal two segments of protarsi a little expanded with ventral hairs. Mesotrochanters with a few scattered, short spines on apical ventral surface. Mesotrochanters with longer more numerous setae forming a sparse brush along posterior ventral portion of metatrochanter. Aedeagus long, sinuate with relatively broad basal portion which is about 2.5x length of parameres. Parameres narrow, evenly narrowing to quite sharp tip. Central lobe as long as parameres. In a number of specimens the parameres are twisted and splayed out, presumably an artefact of preservation, but one that I have not seen in other species.

Female: Basal segment of protarsi not weakly expanded, with ventral hairs. Mesotrochanters with a few sparse, stout setae on ventral face at apex, metatrochanter with similar setae restricted to apical half.

Types

Holotype male: '12°22S 133°01E 6 km SW by S of Oenpelli NT, 30.v.73, at light E. G. Matthews', SAMA.

Paratypes: 4, 'W Australia Mitchell Plateau 14°40S 125°44E 23 Sept 1982 B. V. Timms', SAMA; 4, '13°34S 132°15E', 'Moline Rockhole' 6 km E by E of Mt Daniela 23.v.1974, NT T. Weir and T. Angeles', NTM; 6, '12°32S 132°50E Koorgarra 15 km E of Mt Cahill NT, 15.xi.1972, T. Weir and A. Allwood', NTM; 11, 'NT UDP Falls, 18–19th July 1980, M. B. Malipatil Freshwater Pool', NTM; 20, '12°49S 132°51E, 15 km E by N of Mt Cahill NT, 29.x.72, light trap, E. Britton', ANIC.

Distribution

Northern Territory

8 km E by N of Mt Cahill, NTM; 19 km E by N Mt Cahill, NTM; Junction of Arnhem Hwy and Oenpelli Rd, NTM; Kambolgie Ck, SAMA; Koongarra, NTM; Wildman R, NTM.

Remarks

Virtually indistinguishable from *A. tibialis* and *A. punctatus* other than by sexual characters. Males can be easily separated from *A. punctatus* by the lack of a large bifid labrum, from *A. tibialis* by the weaker development of setae on the mesotrochanters. In *A. tibialis* the mesotrochanter setae are longer and denser often to the extent of matting together. They are also more restricted to the apical portion of both meso- and meta-trochanters than in *A. yalumbaboothbyi.*

Separation of female specimens is more difficult. Female *A. punctatus* have the prolegs pale yellow with a more or less obviously darker terminal portion to the tibia. In both *A. yalumbaboothbyi* and *A. tibialis* the tibiae lack the darker apical portion. The setae on both meso- and meta-trochanters of female *A. yalumbaboothbyi* and *A. punctatus* are small and sparse. In *A. tibialis* they are more developed particularly on the mesotrochanter.

Acknowledgments

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References

BALFOUR-BROWNE, J. 1939. Contribution to the study of the Palpicornia Part III. *Annals and Magazine of Natural History* **11**(4): 289–310.

BLACKBURN, T. 1888. Notes on Australian Coleoptera with descriptions of new species. *Proceedings of the Linnean Society of New South Wales* **111**(2): 805–875.

BLACKBURN, T. 1898. Further notes on Australian Coleoptera, with descriptions of new genera and species. *Transactions of the Royal Society of South Australia* **22**: 221–233.

ERICHSON, W. F. 1843. Beitrag zur Insecten-Fauna von Angola, *in:* besondere Beziehung zur geographischen Verbreitung der Insecten in Afrika. *Archiv für Naturgeschichte* **9**: 199–267.

FABRICIUS, J. C. 1801. Systema Eleutheratorum...I, 24+506pp. Kiliae.

FAIRMAIRE, L. 1879. Descriptions de Coléoptères nouveaux ou peu connus du Musée Godeffroy (Hydrophilidae). *Journal Museum Godeffroy* **24**: 80–83.

HANSEN, M. 1991. The Hydrophiloid Beetles. Phylogeny, Classification and a Revision of the Genera (Coleoptera: Hydrophiloidea). *Biologiske Skrifter* **40**: 367pp.

KRAATZ, G. 1883. *Allocotocerus* nov. gen. Hydrophilidarum. *Deutsche Entomologische Zeitschrift* **27**: 14–15.

ORCHYMONT, A. 1932. Zur Kenntnis der kolbenwasser Käfer (Palpicornia) von Sumatra, Java und Bali. *Archives Hydrobiologica*. Supplement Band IX (Tropische Binnengewassen 11): 623–714.

ZAITZEV, F. A. 1908. Catalogue des Coléoptères aquatiques des familles Dryopidae, Georyssidae, Cyathoceridae, Heteroceridae et Hydrophilidae. *Trudy russkogo Entomologicheskogo Obshchestva* **38**: 283–420.

DOUGLAS MAWSON: THE GEOLOGIST AS EXPLORER

D. W. CORBETT

CORBETT, D. W. 1998. Douglas Mawson: the geologist as explorer. *Records of the South Australian Museum* **30**(2): 107–136.

Douglas Mawson was a born explorer. His professional career as a geologist and academic in Australia demonstrates this aspect of his character as clearly as his exploits in the Antarctic. Science and exploration dominated his life and motivated his endeavours, and the inseparable link between them was his pursuit of knowledge of glaciation—both ancient and modern. This paper reviews the diversity and wide geographical extent of his geological investigations, principally in South Australia, during the first half of the twentieth century at a time when the geology of large areas of the State was still largely unknown. The manner of his achievement and his distinguished contribution to the advance of geological knowledge in South Australia exemplify Mawson as the explorer-geologist.

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Douglas Mawson was a geologist with a broad scientific background and diverse interests within his discipline, as a review of his publications will verify (see Innes and Duff 1990). Known and honoured as one of the great Antarctic explorers, the prime motivation behind his achievement was the pursuit of scientific knowledge, which he coupled with the innovative use of the latest available technology. With the exception of Otto Nordenskjold, geologist and leader of the Swedish Antarctic Expedition (1901–03), Mawson was the only science-trained expedition leader in the heroic age of South Polar exploration and his approach marked the beginning of the modern age of Antarctic exploration.

Mawson's career as a geologist and his scientific reputation were built in South Australia during his many years in the geology department at the University of Adelaide. While this paper focusses on the academic aspects of Mawson's life more than his Antarctic exploits, it is impossible to disentangle the two strands of endeavour. Down south he was the scientific-explorer; in the arid outback of South Australia he was the explorer-scientist. His major researches inextricably linked the two vastly different environments, for it was the opportunity to study an ice-age at first-hand and to equip himself better as an interpreter of past glaciations that inspired Mawson to venture south with Shackleton in 1907.

The circumstances of time and place (early twentieth century South Australia, much of it little known geologically) and his life-long interests in glaciation, ancient and modern, determined that Mawson the geologist and Mawson the explorer were one and the same and through his extensive investigations in South Australia he personifies both the adventurous and the enquiring spirit.

Mawson's Antarctic exploits have been chronicled by historians, fellow-expedition members and in his own classic account 'The Home of the Blizzard'. His career as a scientist,and notably an assessment of his geological work, have been less well treated, although aspects of them are covered in the biography by his wife (Mawson 1962) and by Alderman (1967); by Parer and Parer-Cook (1983); in the biographical summary by Jacka (1986) and by Sprigg (1986). This paper presents a review, with emphasis on Mawson's career as a geologist in South Australia and his contribution to geological knowledge of the State.

Early Years

As one of the first generation of geologists trained in Australia, Mawson brought an Australian rather than European perspective to his work. Although born in Yorkshire, England on the 5th May, 1882, he was only two years old when his family migrated to Sydney and he grew up staunchly independent and thoroughly Australian in outlook—as the promotion of his Antarctic expeditions was to demonstrate. He

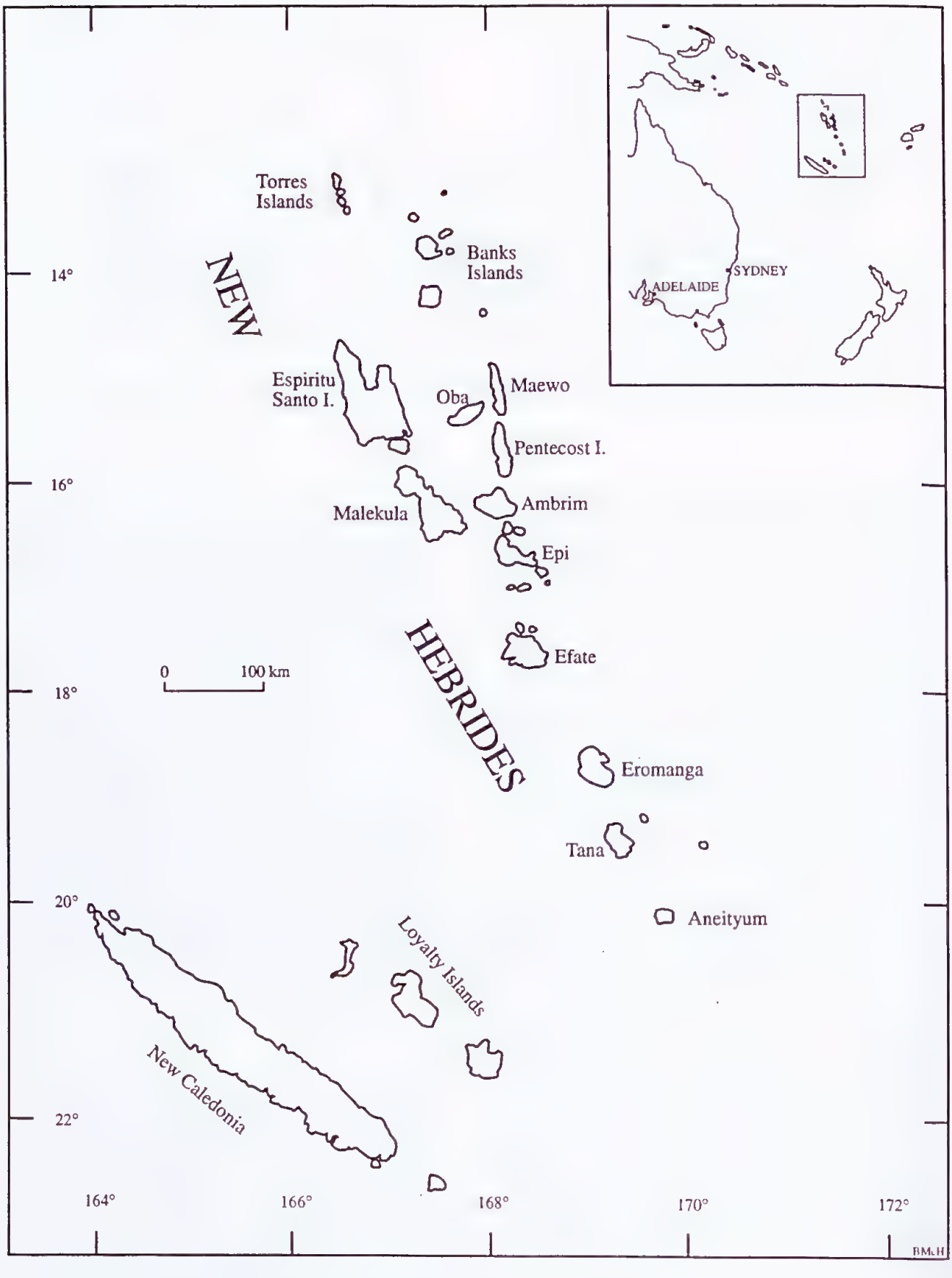


FIGURE 1. Locality map. The New Hebrides archipelago in the south-west Pacific.

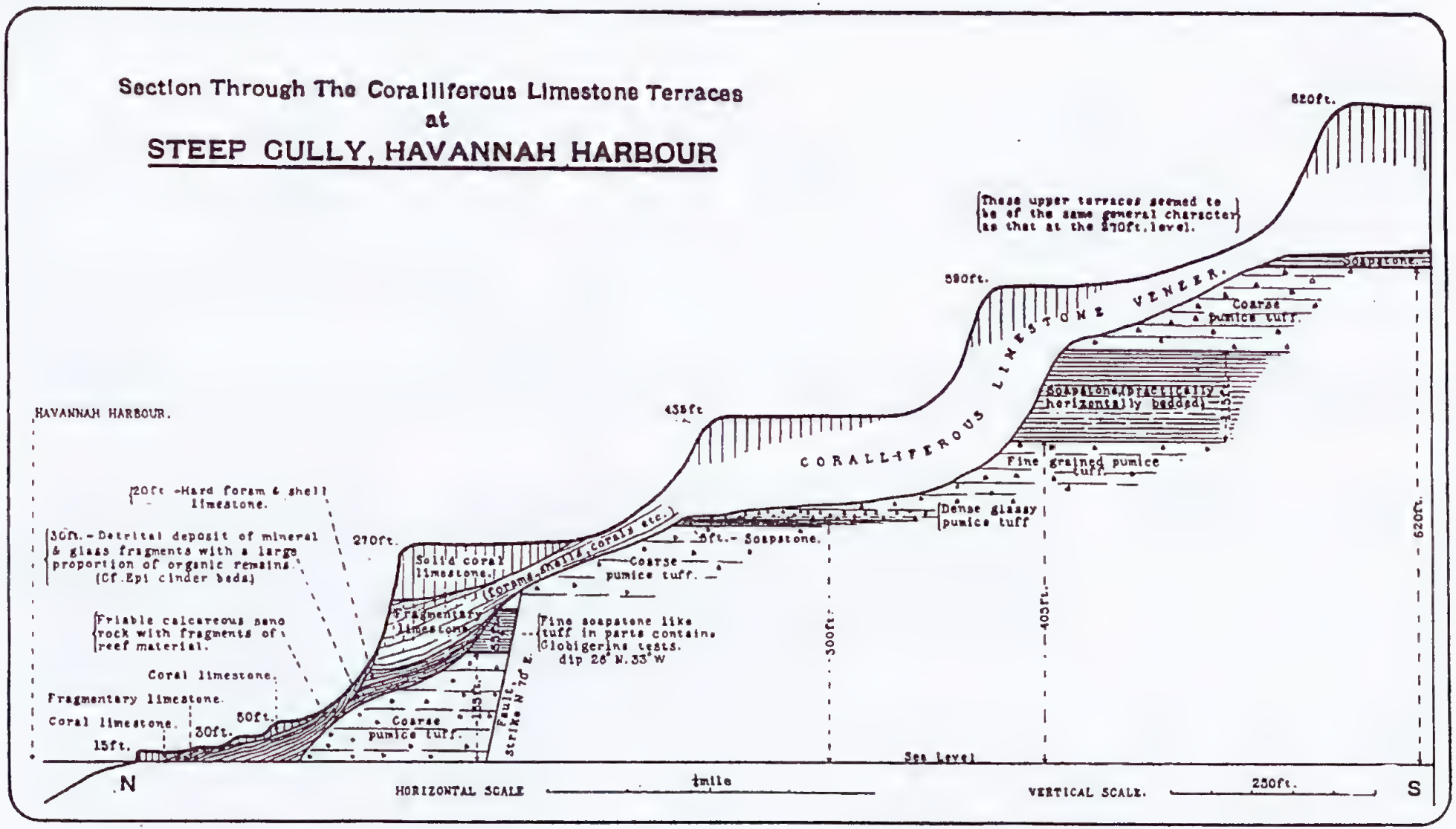


FIGURE 2. Mawson's stratigraphic cross-section of Efate. Proceedings, Linnean Society NSW 3, 1905.

entered the University of Sydney in 1899 at the age of 16, doing well in Physics, Chemistry and Mining on the way to his Bachelor of Engineering degree in 1901. But it was in geology that he excelled, gaining first class honours in 1900 and being awarded the petrology prize, and subsequently, in 1905, completing a B.Sc in geology. His inspiration came from the charismatic personality and the dynamic teaching of the Professor of Geology, T. W. Edgeworth David, who in turn was quick to recognise the abilities of the young science student. David was to become Mawson's mentor, fellow expeditioner and lifelong friend and confidant.

One of David's many preoccupations was ancient glaciation. As a young geologist in Britain he had followed with interest the debate on the nature of the latest (Pleistocene) Ice Age and the evidence of a much older glaciation (Permo-Carboniferous) discovered in India. Working for the New South Wales Geological Survey in the late 1880s he confidently identified glacial deposits in the Permo-Carboniferous rocks of the Hunter Valley. In 1901 he visited Mount Kosciusko where he immediately recognised the work of glaciers in the tarns, moraines and ice-sculpted valleys in the high country (David *et al.* 1901)—his views effectively settling a dispute that had continued ever since W. B. Clarke had reported evidence of glaciation there half a century earlier. Meanwhile in South Australia Walter Howchin had discovered glacial sediments, older than any known to that time, in the Sturt Gorge near Adelaide (Howchin 1901). These deposits (the Sturt Tillite) were assigned to the Cambrian but were later shown to be even older (late Precambrian), extending the evidence of past glaciation in both time and space and acting as a spur to the search for further clues to a former frigid earth.

David was Australia's first 'national' geologist, with interests spread well beyond his base in New South Wales. He had particularly strong links with South Australia through Walter Howchin, with whom he had collaborated in the field on such diverse matters as Cambrian fossils and glacial geology. It was perhaps inevitable that Mawson should become interested in these new developments which were extending the frontiers of Australian geology but his studies initially led him in other directions. In 1902 he was appointed Junior Demonstrator in chemistry and the following year he took six months leave of absence to make a trip to the South West Pacific.

The New Hebrides 1903

Mawson's first opportunity to explore and engage in adventurous fieldwork was due to the initiative and recommendation of David, who had a long-sustained interest in the geology of the Pacific basin. It was to prove a testing assignment for Mawson, requiring him to work under arduous and at times dangerous conditions, making the most of general short excursions from the ship as it sailed through the island archepelago, strung out over a vast area of ocean. Little known geographically away from the coastal fringe, the interiors were rugged and thickly covered with dense rainforest making access difficult while the native inhabitants had a reputation for being unpredictable and at times hostile.

Apart from a scanty record of previous investigations, the New Hebrides (Fig.1) were a geological 'terra incognita' and for Mawson a challenge he was eager to meet: 'A great field was now open before us ... nothing has yet been gleaned as to the true nature of the rocks forming this extensive chain of islands'.

Mawson (and W. F. Quaife, a biologist) arrived at Vila, on the island of Efate and the chief town in the group on 13 April 1903. His first observations were made in the low hills around the town where a raised coral reef overlay volcanic sediments. This general geological situation was confirmed at locations further north along the coast where much thicker reef deposits overlay the 'foundation rocks'—a variable series of tuffaceous volcanics including agglomerates and pumice-rich beds (Fig. 2).

From Efate the ship steamed north to Malekula where Mawson wrote: 'The natives of Malekula are the most uncertain of any of the inhabitants of the group, having not yet abated from cannibal habits; indeed war was raging between the Natives ... at the time of our visit. For this and other reasons we were unable to examine this region very thoroughly'. Nevertheless he was able to make some investigations and excursions into the interior. Reaching Espiritu Santo, the largest island, a base was established at the mission settlement of Tangoa on the south coast and an assault made on Losumbuna (5 520 feet), the highest mountain in the New Hebrides. The interior mountains had never been explored by Europeans and the challenge was irresistible. Accompanied by three native guides, Mawson and Quaife negotiated two subsidiary peaks before bad weather, difficult terrain and, crucially, their guides' refusal to continue, forced a retreat.

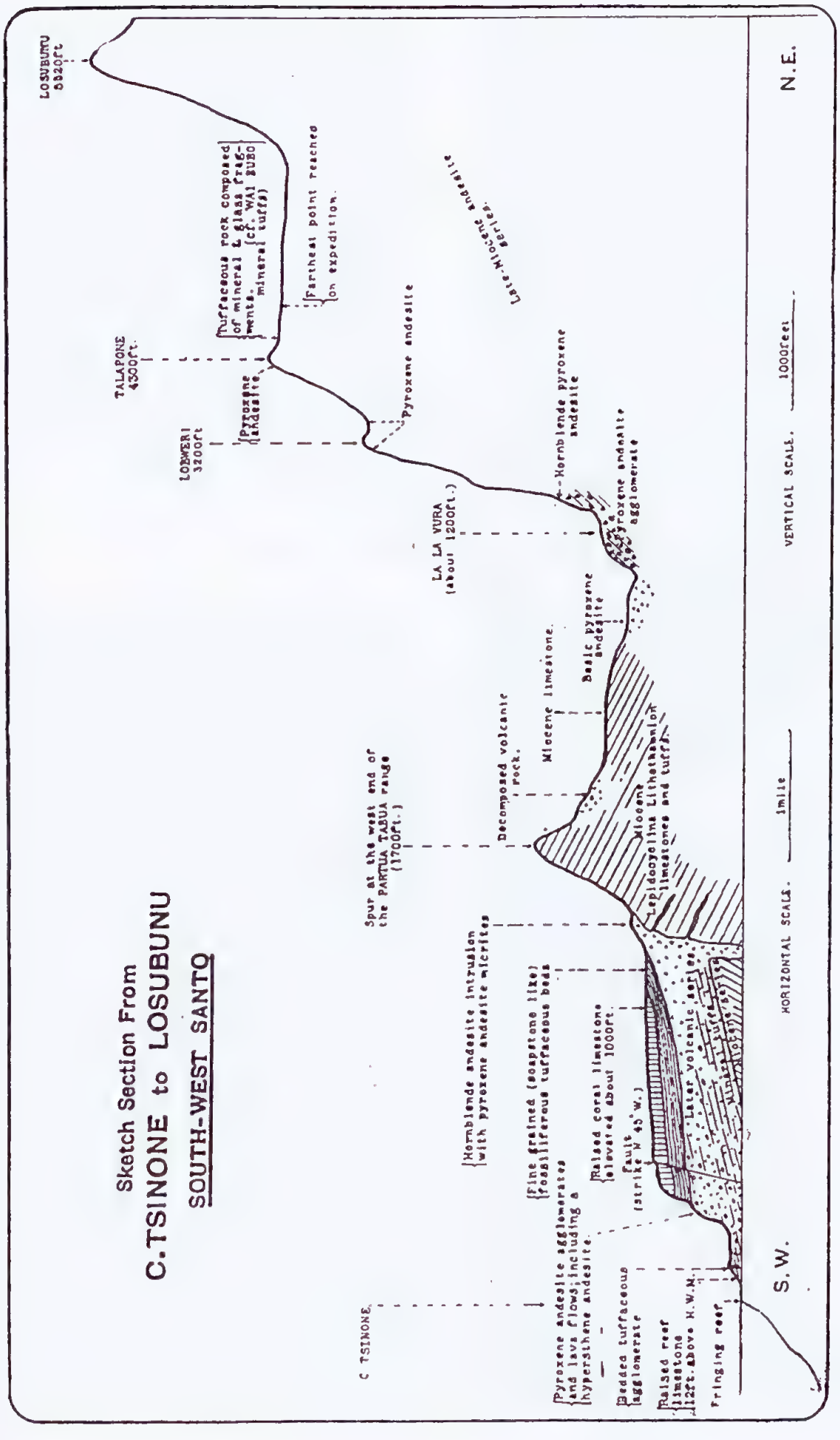

Sketch Section From
C. TSINONE to LOSUBUNU
SOUTH-WEST SANTO
C. TSINONE
S. W.
N. E.
LOSUBUNU 6820ft.
TALAPONE 4300ft.
LOBWERI 3200ft.
LA LA VURA (about 1200ft.)
Spur at the west end of the PARTUA TABUA range (1700ft.)
Pyroxene andesite
Tuffaceous rock composed of mineral & glass fragments. (cf. WAI BUSO mineral tuffs)
Farthest point reached on expedition.
Late-Miocene andesite series.
Pyroxene andesite
Hornblende pyroxene andesite
Pyroxene andesite agglomerate
Basic pyroxene andesite
Miocene limestone.
Decomposed volcanic rock.
Hornblende andesite intrusion with pyroxene andesite micrites
Fine grained (soapstone like) fossiliferous tuffaceous beds
Raised coral limestone elevated about 1000ft.
Fault (strike N 45° W.)
Miocene Lepidocyclina Lithothamnion limestones and tuffs.
Pyroxene andesite agglomerates and lava flows; including a hypersthene andesite.
Bedded tuffaceous agglomerate
Raised reef limestone 12ft. above H.W.N.
Fringing reef
Later volcanic series.
Miocene tuffs
HORIZONTAL SCALE. 1mile
VERTICAL SCALE. 1000feet

FIGURE 3. Mawson's section across Santo. Proceedings, Linnean Society NSW 3, 1905.

Although disappointed at not reaching their objective, Mawson collected specimens and made sketch sections of the rugged hinterland (Fig. 3). Fieldwork proved more productive along the coast where three separate pyroclastic units intruded by a variety of igneous rocks were found. An earlier report of older basement rocks (gneiss) in this part of the island could not be confirmed despite diligent searching.

The northern-most islands in the chain were covered in a cursory reconnaissance, but enough to confirm the volcanic nature and essentially basic composition of the Banks Group. Arriving back in Vila in mid-August after four months away, the expedition was greeted by a minor earthquake with another tremor following a few days later—enough to indicate the seismic instabilty of the region. Finally, investigations in the Havannah Harbour area provided key sections in the local sequence of volcanic sediments and overlying reef deposits.

The New Hebrides expedition was inevitably very much a reconnaisance and Mawson was keenly aware of the limitations of his survey. One of the strengths of his published report (Mawson 1905) was his inclusion of all previous references, both published and unpublished, to the geology and physical features of the islands. The general seismicity of the region, already well documented, and which Mawson himself experienced, he attributed to local volcanic sources, recognising also the importance of regional tectonic movements along major faultlines. He wrote: 'before long numerous seismological stations will be distributed through the South Pacific Islands, as only by analysing such data as would result, can definite decisions regarding the present earth-movements in this much-troubled area be arrived at'. It was to be fifty years before that hope began to be realised.

An anticipation that because the old rocks of nearby New Caledonia were mineral-rich, the New Hebrides might be similarly endowed was quickly dispelled because of the geological youthfulness of the islands. Sulphur deposits and iron-bearing sands were the only resources considered to be of possible future commercial value. Within the regional context of the Pacific basin, Mawson viewed the New Hebrides island arc as of late Tertiary age, one of a series of parallel arcs which were remnants of a much fragmented continental mass. Folding and over-thrusting, associated with volcanicity, against a rigid foreland lying to the west (New Caledonia), had been followed by major faulting and sea-floor subsidence.

The evidence for elevation which most impressed Mawson were the raised coral reefs. These capped the Tertiary deposits and ranged in terraces rising to over 2 000 feet (609 metres). They were estimated to be post-Pliocene in age, and gave a clear indication of continued tectonic activity since the middle Tertiary.

His published account of the New Hebrides expedition put the islands on the map geologically and established Mawson as a resourceful and perceptive field worker, competent in many areas of geology and with a flair for synthesis. He foreshadowed many of the more recent interpretations of south-west Pacific region geology made in the light of Plate Tectonic theory, with the New Hebrides viewed as an island arc of volcanic lavas and pyroclastic rocks and intrusions adjacent to a deep ocean trench and above a steeply dipping seismic zone.

Early Researches

On returning to the University, Mawson was soon involved in research (with fellow student and later Antarctic explorer Griffith Taylor) on the igneous rocks in the Bowral-Mittagong area, south-west of Sydney. The Mittagong study (Taylor and Mawson 1903) was the first of many on the petrography and petrology of igneous rocks in their regional setting which was to remain a prime interest in the years ahead. About this time Mawson also began investigations into the radioactive properties of minerals. This was a pioneer study in Australia, closely following the discovery of radioactivity by Becquerel in 1896 and the follow-up work by the Curies which led to the isolation of radium in 1898 and the recognition that uranium and thorium-bearing minerals were radioactive. Mawson reviewed these recent researches and carried out tests on natural waters, mud, soil and air. He was required to construct his own analytical equipment, notably a gold-leaf electroscope, and a large number of Australian minerals was tested including the only two known occurrences of uranium-bearing minerals in Australia and which gave the predicted high readings. The other minerals found to test positive were mainly monazites from various tin-fields around Australia. His short paper (Mawson & Laby 1904) marked the beginning of a life-long interest in the geological occurrence of radioactive minerals and their economic potential.

South Australia 1905

Late in 1904, Mawson, with the support and encouragement of David, was appointed to the position of Lecturer in Mineralogy and Petrology at the University of Adelaide. He arrived to take up his academic duties full of enthusiasm and with high expectations but was immediately confronted with a lack of suitable accommodation and facilities for geology due to the University's chronic shortage of funds. Frustrations developed which were to dog him for many years, including the necessity to forge a working relationship with the only other member of the Geology Department, Walter Howchin. Already with an established international reputation and with a great deal of experience of South Australian geology, Howchin was 60 years of age when Mawson, 23, arrived on the scene. It seems there were tensions from the start. The question of 'spheres of activity' (Mawson's phrase) provided an immediate and ongoing irritant, to be temporarily removed when Mawson went south in 1907.

The geology of South Australia was known in broad outline at the beginning of the century (Corbett *et al.* 1986) This was due predominantly to the work of three men: Ralph Tate, the first geologist appointed to the University (1875–1901); Walter Howchin, Methodist Minister and enthusiastic amateur until his appointment to the University after Tate's death in 1901; and H. Y. L. Brown, the first Government Geologist who was to act as a one-man Geological Survey from 1882 until 1912. While Tate and Howchin worked mainly, though not exclusively, close to home in the Mount Lofty Ranges, Brown had been carrying out some epic geological explorations in the northern regions of the State which at that time included the Northern Territory. He published the first geological map of South Australia in 1883, revising it periodically. His 1899 map was a remarkable achievement and in its essentials remains little changed today.

Tate had discovered glacial features at Hallett Cove in 1877; Howchin subsequently demonstrating the widespread evidence for this glaciation outside the Adelaide region and establishing a Permo-Carboniferous age for the event by about 1900. In 1901 Howchin, as mentioned previously, had discovered the much older glacials in the Sturt Gorge, a few miles south of Adelaide. But perhaps the most significant of all the early breakthroughs was the finding of Cambrian fossils in the old rocks on the western flank of the Mount Lofty Ranges (Howchin 1897). Howchin thereafter concentrated much of his effort on determining the stratigraphy of the western ranges.

It was Howchin's clearly expressed 'prerogative' to work in most areas of the State that prompted Mawson to choose the remote Olary-Broken Hill area for his first extensive field investigations. It was a decision both judicious and timely. Not only did this work extend Howchin's researches on the supposed Cambrian rocks of the Mount Lofty Ranges into the Olary Spur and over the border to Broken Hill and the Barrier Ranges, but the problems presented by the region also satisfied his interests in mineralogy, petrology, and stratigraphy and his discoveries were to influence his future involvement with glacial deposits both ancient and modern.

The explorer-geologist was severely tested in the harsh environment near the north-east state border. It was (and is) an arid, inhospitable and sparsely inhabited country. Previous investigations had centred on and around the Broken Hill ore-body itself—the largest silver-lead ore body in the world. While little was known of the origin of the ore-body and its stratigraphic controls, Mawson set himself the task of ascertaining the broader regional context of the deposit. His methods involved covering the ground in a series of traverses on foot, horseback, bicycle and on occasions, by motor vehicle. He was to determine and define two major rock divisions in the Olary-Broken Hill region:

1. An older basement complex of metamorphic rocks including gneiss, schist, amphibolite and granite of Precambrian age which he named the *Willyama Complex*, and
2. A younger series of sedimentary rocks, in part metamorphosed, of assumed Cambrian age including a wide variety of rock types, the most notable and persistent being boulder-beds and related sediments of glacial origin. This he named the *Torrowangee Series*.

In January 1907, the Australasian Association for the Advancement of Science (AAAS), held its meeting in Adelaide and Mawson gave two (unpublished) papers based on his recent field work and particularly concerned with the glacial beds. His interest in these beds and a desire to reach a full understanding of their nature and origin was developing rapidly. Many years later he wrote to Edgeworth David that his commitment to glacial geology dated from December 1906 when his Olary field investigations were well underway. Matters moved very rapidly at the end of 1907. Mawson heard, through David (who was

to join the British Antarctic Expedition), that the leader, Ernest Shackleton, was to visit Adelaide briefly on his way to New Zealand to join the 'Nimrod'. Mawson successfully requested a meeting and volunteered his services for the summer season. Within three days Shackleton had offered Mawson the position as physicist for the duration of the expedition. The opportunity to realise his ambition to experience 'an ice-age in being' was too good to miss. He accepted, quickly arranging for a 'locum' to cover his absence from the University, and left Adelaide before the end of December bound for the Antarctic.

South With Shackleton – the British Antarctic Expedition

David was senior geologist on the expedition with Raymond Priestley, a young man with no formal qualifications in science, as his deputy. Mawson as physicist had no official role in this area. Yet from the start David involved his old student in the geological program and in two of the three main journeys undertaken by the expedition—the ascent of Mount Erebus and the trek to the South Magnetic Pole. Mawson played a crucial role, both as a young and vigorous team member and a valuable contributor to the geological work, which David was quick to acknowledge in his final report (David & Priestley 1914). Here Mawson is referred to as Mineralogist, Chemist and Physicist to the expedition (the study of Antarctic ice—its crystallisation, granulation and other properties—was considered by David as much a matter of mineralogy as of physics). The report incorporates much of Mawson's thinking and his contribution to it was wide-ranging, covering mineralogy and petrology and stratigraphy, as well as economic geology implications and broad-scale considerations of Antarctic geology within a global context.

Mawson and David were both in the small party which reached the summit of Mount Erebus (3 794 m) on 8 March. Mawson made a traverse map of the eight day journey which provided its share of adventures (Shackleton 1911). He also took photographs and collected rock specimens. Later that winter (June 14) the volcano was seen in eruption from their base, steam issuing from the crater, although no lava was observed on the flanks of the cone.

With the coming of spring, preparations were made for the two major assaults of the expedition; Shackleton's push for the geographic pole and an attempt by a northern party (David, Mawson and McKay) to reach the South Magnetic Pole. The route was along the coast of Victoria Land as far as the Drygalski Glacier Tongue, where they were to turn inland climbing onto the Polar Plateau towards the pole. A general survey of the geology of the coast and where possible of the Western Mountains was an important part of the program. The early stage of the journey was along the edge of the sea-ice with outcrops confined to occasional rocky bluffs projecting from under the ice-cap. Observations were made at Cape Bernacchi (marble), Cape Irizar, Granite Harbour and Depot Island. The rocks encountered were highly altered (metamorphic) and included gneiss and schist together with granite (itself metamorphosed) and basic lavas. Looking inland through field-glasses, these lavas were seen at a higher level to overlie the granites and in turn to be succeeded by stratified rocks which were taken to be the Beacon Sandstone, discovered and described by Ferrar (1907) on Scott's first expedition (1901–03). David described Depot Island as '... most wonderful geologically and a perfect elysium for the mineralogist'. Mawson relished the variety of rocks and minerals they found, among them epidote, pyrite, copper pyrites (chalcopyrite), garnet and manganese oxides, some of which he thought might prove of economic value. Certain of the rocks, notably the gneiss and granite reminded him of those in the Broken Hill area. Meanwhile the ubiquitous glacial debris (moraine) dumped at the melting ice-front was a rich source of supplementary evidence of what lay further inland, below the ice-cap. Erratics at one locality were very similar to the Victor Harbor Granite.

The ascent of the plateau became an ordeal and any thoughts of geology were replaced by concentrating on the dash for the magnetic pole. The elusive and ever-wandering point was reached on 16 January 1909. The return journey proved a battle for survival and the party was very fortunate to make the rendezvous with the 'Nimrod' and safety.

The information collected by the Magnetic Pole party made a valuable contribution to the geological results of the expedition. Notably, David and Mawson were able to build on Ferrar's earlier work and show that Victoria Land comprised a basement complex of metamorphic, igneous and mineral-rich rocks of assumed Precambrian age, overlain by a sedimentary sequence, which, on the limited evidence available, included rocks intermediate in age

FIGURE 4. Mawson, seated, on his return from Antarctica, 1909. Howchin stands at his right shoulder. Photo: P. Driver-Smith.

between the basement and the Beacon Sandstone.

For Mawson the expedition proved a stimulating and scientifically rewarding experience. His desire to experience modern glacial processes in action had been achieved and the insights gained were to be developed on his next journey south and later applied to the ancient glacial deposits of South Australia. Above all, his participation in the Shackleton expedition had determined his lifelong interest in the southern continent.

Interlude

Mawson returned to Adelaide in April 1909 to a hero's welcome (Fig. 4), but within a few weeks he was back in the Olary–Broken Hill country, hiring a horse and dray and continuing his investigations among the mineralised rocks and the ancient glacial beds of the arid north. After completing his fieldwork, he spent some time in Broken Hill writing up his results, and on laboratory studies of the mineralogy and petrography of the key rock types. He was particularly impressed by the pegmatites which were such a prominent feature of the region and wrote: 'In no other part of the world can pegmatite formations occur on a more extensive scale'. The study of pegmatites was at that time in its infancy and Mawson recognised that in Olary he had evidence of their importance as 'a connecting link between the igneous rocks and the differentiated products economically worked as ore deposits'. His fieldwork, and the subsequent published review (Mawson 1912a; Fig. 5) of all aspects of the geology and economic geology of this important and yet little known mineral province, was a major contribution to South Australian geology and earned him the degree of D.Sc. from the University of Adelaide in 1909.

While in Broken Hill he examined and valued several mineral collections from the mines on behalf of the South Australian Museum. Some of them included specimens of outstanding quality. Mawson had first acted for the Museum in 1906, when he had successfully acquired the Dunstan Collection from the Wallaroo Mines. In 1908 he was appointed Honorary Curator of Minerals, thus beginning a long and productive association with the Museum which was to last his lifetime, and which became crucial in later years, as no full-time curator responsible for the collection was appointed until 1956. The Mawson-Museum connection cannot be treated in any more detail here.

Early in December 1909, Mawson left Adelaide for London on board the SS 'Mongolia'. He was

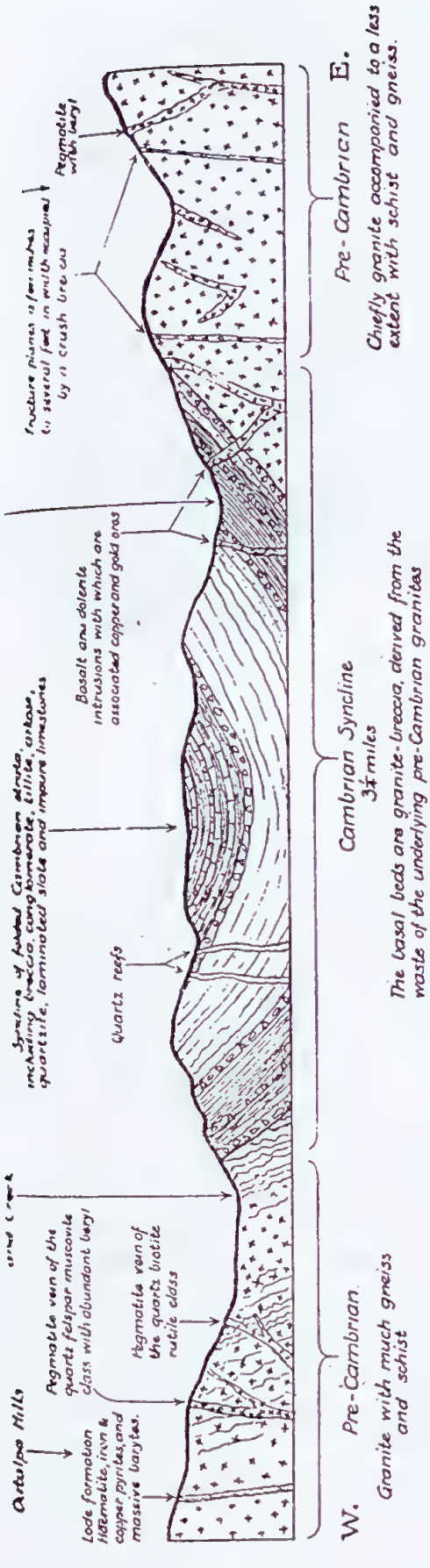

E.
Pre-Cambrian
Chiefly granite accompanied to a less extent with schist and gneiss.
Pegmatite with beryl
Fracture planes of various trends to several feet in width occupied by a crush breccia
Basalt and dolerite intrusions with which are associated copper and gold ores
Cambrian Syncline
3½ miles
The basal beds are granite-breccia, derived from the waste of the underlying pre-Cambrian granites
Synclinal of fossil Cambrian strata, including breccia, conglomerate, tillite, arkose, quartzite, laminated slate and impure limestones
Quartz reefs
Pegmatite vein of the quartz felspar muscovite class with abundant beryl
Pegmatite vein of the quartz biotite rutile class
Lode formation Hæmatite, iron & copper pyrites, and massive barytes.
Pre-Cambrian.
Granite with much gneiss and schist
W.

FIGURE 5. Mawson's interpretation of the geology near Olary, South Australia (1912b). Courtesy ANZAAS.

keen to go to the Antarctic again and full of ideas for a scientific program that he hoped would appeal to either Shackleton or Scott, both of whom he knew had plans for expeditions south. Scott was very keen to enlist Mawson (even offering him a place in the final polar party), but was not prepared to consider any modification of his own plans which were already well advanced. Discussions were long and frank but when Mawson learned that the position of chief scientist (which he might have accepted) had been filled and his proposal for a western party to explore King George V Land unacceptable, he declined Scott's offer. He was simply not prepared to compromise his purely scientific approach to Antarctic exploration. As for Shackleton, initially Mawson maintained friendly relations with his former leader, even visiting a gold prospect in Hungary which Shackleton was convinced would make his fortune (and Mawson's too if he came in with him as an investor). But becoming increasingly disillusioned with Shackleton's erratic behaviour and lack of firm plans, Mawson followed him to America in an attempt to pin him down; and the two signed an agreeement that an expedition would leave late in 1911 and should Shackleton be unavailable as leader Mawson was to take over and receive all Shackleton's support and assistance in raising funds. Ever the realist, it was clear to Mawson that the responsibility for mounting the expedition was most likely to be his and so it proved. He was then faced with the daunting task of raising funds quickly and in competition with Scott who had a head start and the advantage of being based in London. Mawson returned to Adelaide. For the next eight years the Antarctic was to dominate his life. But for a brief interlude he returned to academic life and his research activities and to these we now return.

Radioactive Minerals: Radium Hill and Mount Painter

Mawson's involvement with radioactive minerals had been renewed soon after his arrival in South Australia when in May 1906 carnotite, a highly radioactive mineral, was found in ore taken from a mine 24 miles east-south-east of Olary. H. Y. L. Brown visited the site and issued a report in which he speculated that the mineral was a decomposition product of primary uranium ores occurring at depth. In August, Mawson obtained samples which he passed over to E. H. Rennie, Professor of Chemistry, for analyses which

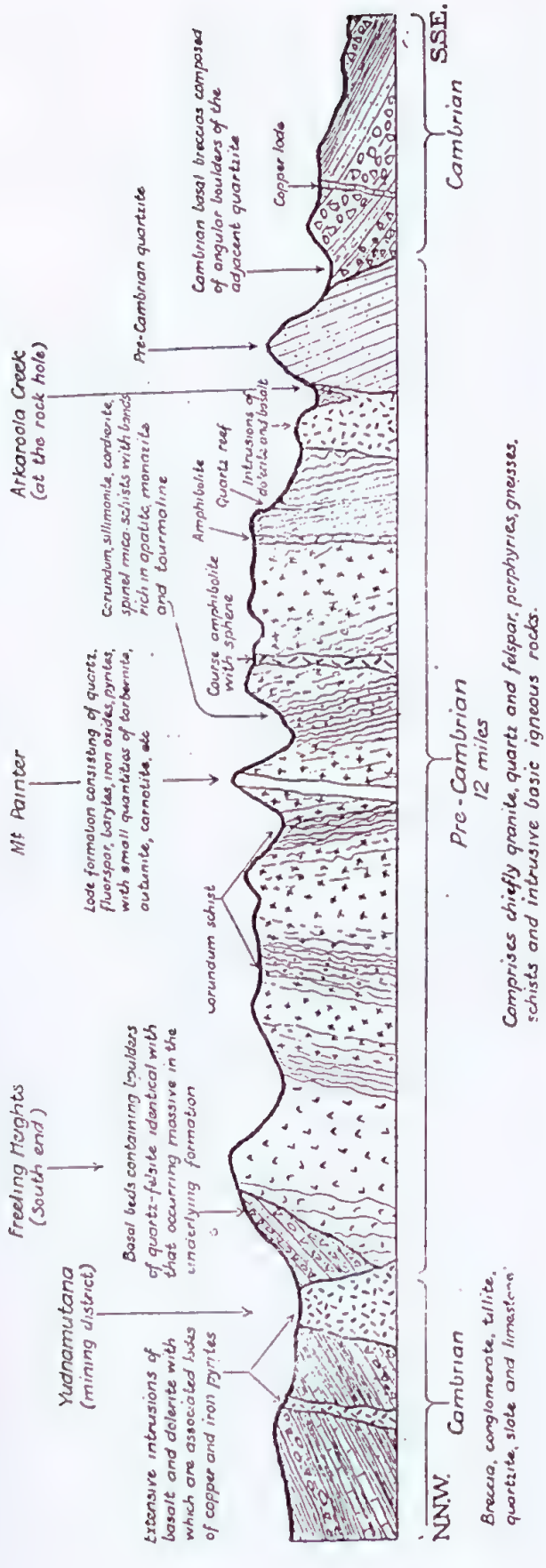

Arkaroola Creek (at the rock hole)
Mt Painter
Freeling Heights (South end)
Yudnamutana (mining district)
Basal beds containing boulders of quartz-felsite identical with that occurring massive in the underlying formation
Intensive intrusions of basalt and dolerite with which are associated lodes of copper and iron pyrites
Corundum schist
Lode formation consisting of quartz, fluorspar, barytes, iron oxides, pyrites, with small quantities of torbernite, autunite, carnotite, etc
Course amphibolite with sphene
Corundum, sillimonite, cordierite, spinel mica-schists with bands rich in apatite, monazite and tourmaline
Amphibolite
Quartz reef
Intrusions of dolerite and basalt
Pre-Cambrian quartzite
Cambrian basal breccias composed of angular boulders of the adjacent quartzite
Copper lode
NNW.
SSE.
Cambrian
Pre-Cambrian
12 miles
Comprises chiefly granite, quartz and felspar, porphyries, gneisses, schists and intrusive basic igneous rocks.
Cambrian
Breccia, conglomerate, tillite, quartzite, slate and limestone

FIGURE 6. Geological cross-section in the Mt Painter – Arkaroola area (1912b). Courtesy ANZAAS.

suggested that black minerals initially identified as magnetite, were far more complex. This prompted Mawson to visit the mine and make a detailed survey of the exposed reefs which had been pegged originally in the belief that the prominent black mineral was a tin-bearing ore. Further examination showed that while the magnetic iron/titanium mineral was dominant in the main reef, a rarer black mineral with a distinctive and very brilliant lustre also occurred as grains, streaks and cubic crystals. Analysis shows that in addition to a high percentage of iron and titanium the mineral also contained rare earth elements together with uranium, vanadium and chromium. Mawson proposed the name Davidite for what he believed to be a new mineral species in honour of his former teacher (Mawson 1906). He also identified Roscoelite, a bright green vanadium-bearing mineral. At a time when knowledge of radioactive minerals was in its infancy, Mawson recognised the deposit as a significant discovery, possibly of economic importance, and named the locality Radium Hill. He was optimistic but cautious in his appraisal: 'This body of radio-active ore is, in the matter of quantity, much the most important yet discovered in Australia. Its low grade, however, introduces serious difficulties to commercial enterprise in this direction'. Radium Hill was to have a long but intermittent history based on the working of its radioactive lodes (Fig. 7), and Mawson was to renew his interest in the deposit in the 1920s.

Mawson visited the Flinders Ranges for the first time towards the end of 1910, during his short spell in Adelaide between Antarctic expeditions. He had received a visit from W. B. Greenwood, the owner of Umberatana Station, who had brought some specimens of a bright green mineral which Mawson identified as torbernite, an hydrated phosphate of copper and uranium. Greenwood had been prospecting in the northern ranges on behalf of the Mines Department for several years and had become annoyed when specimens, including the green mineral, which he had left at the Department some time before had not received attention; whereupon he had retrieved them and taken them to the University. Excited by the prospect of another radioactive mineral deposit in South Australia, Mawson headed north and, with Greenwood and renowned prospector Harry Fabian, made an examination of the geology and mineral occurrences in this most rugged and inaccessible part of the Flinders, attempting to place the local geology in the broader regional context (Fig. 6). The short visit marked the

beginning of his long and fruitful association with the geology and mineral resources of the region and his field notebook for the trip is full of detail of his observations and the excitement of discovery; for example: 'The results of my recent journey have been in the highest degree satisfactory... My main objective was the investigation of the metamorphic rocks eastward of Yudnamutana in connection with the interpretation of the Barrier Ranges, a subject in which I have long been absorbed...'

With regard to the potential of the uranium-bearing lodes he wrote : '... the outcrop is on the whole low grade, though richer patches are met with at intervals. Improvement may be expected below. The ore can be treated very inexpensively and this will offset the low-grade character. So far as I am aware this is the most extensive uraniferous lode formation in the world'. The back of his field notebook contains estimates of costing for ore extraction, transport, freight and handling, including comparisons for treatment on the spot, at Port Pirie or in England. There would be a need for roads and wells and for camels to bring out the ore. If the grade proved high enough, he foresaw the setting up of a company to work the ore—the Radium Extraction Company. He even worked out the capital required – £20 000. These estimates may have been doodlings around the campfire, at the latest they were put on paper soon after his visit, and they have an immediacy which reveal Mawson's keen interest in the region, its economic potential and his desire to be part of the action. He was not to return north for more than a decade. Over the next few years some intermittent mining activity took place at Mount Painter, but with the outbreak of World War I activity ceased.

South Again – The Australasian Antarctic Expedition (AAE) 1911–14

In January, 1911, Mawson gave a lecture to the combined geology and engineering groups at the annual meeting of the AAAS in Sydney. It was a fund raising exercise designed to appeal to national pride as well as pointing out the scientific and future economic potential of the southern continent. He stressed that: 'the collection of scientific data (was) obligatory upon us ... its mountains were blessed with mineral resources ... (and) it holds among its fossil strata secrets especially interesting to Australians'. Science was to be linked to technology and the latest developments—the wireless and motor sledges—still to be tested down south, were seen as a vital aid to scientific exploration. The burdens of leadership were enormous leaving little time for any geological researches of his own, but Mawson recruited a strong team of four geologists who were to carry out valuable surveys over a great expanse of territory. Cecil Madigan, later to join his leader at the University of Adelaide, was appointed meteorologist.

Reaching the area selected for the expedition's base, the expedition ship 'Aurora' had great difficulty in breaking through the ice barrier and was forced to cruise westward; Mawson had hoped to find the Antarctic continent in these latitudes bounded by a rocky and attractive coast like that in the vicinity of Cape Adare, the nearest well-explored region. The poor prospects of carrying out extensive geological work under such conditions must have been a blow, but Mawson was impressed and awed by the sheer physical presence and power of the ice and its dominance of the environment: 'The land was so overwhelmed with ice that, even at sea-level, the rock was all but entirely hidden. Here was an ice-age in all earnestness; a picture of northern Europe during the Great Ice Age some fifty thousand years ago' (Mawson 1915, 1996 p. 40).

The main base was established at Cape Denison (Commonwealth Bay) and a western base party, including two geologists, some 1 500 miles (2 400 km) further along the coast to the west on the edge of the Shackleton Ice-Shelf. The vicinity of Cape Denison was comparatively ice-free, and the geologists were able to study glacial erosion and deposition at first hand. The rocks outcropping near the main base were predominantly metamorphic—folded and contorted gneiss and schist of presumed Precambrian age. Evidence of ore-bearing minerals was also found, among them iron, copper and molybdenum which Mawson believed gave promise of larger bodies in the vicinity and indicated the probability of mineral wealth beneath the continental ice-cap. Around the edge of the ice margin, the terminal moraines were 'a veritable museum'. Rocks, showing every variety in colour and form, were assembled, transported from far and wide over the great expanse of the continent ... 'The story of the buried land to the south is in large measure revealed in the samples brought by the ice and so conveniently dumped' (Mawson 1915, 1996 pp. 74–76). After a particularly severe winter with hurricane force winds, the summer journeys commenced, and much valuable scientific work carried out. A western party made a particularly

interesting find, the first meteorite from Antarctica, duly named the 'Adelie Land Meteorite', and the first of many to be found in later years.

Mawson himself, with Ninniss and Mertz and the dogs, set off on the longest and most ambitious of all the journeys, striking east on a southerly course in an attempt to cover as much territory as possible in the time available. The story of that harrowing journey which cost the lives of both of Mawson's companions, and of his miraculous return against overwhelming odds just in time to see the 'Aurora' disappear over the horizon, is an epic story of endurance, fortitude and sheer will power which has been well told by Mawson himself in 'The Home of the Blizzard' (Mawson 1915) and by Bickel (1977). Mawson and the small remnant of the expedition left behind to search for him had to face another Antarctic winter. The 'Aurora' returned in December 1913 and on the 26 February 1914, Mawson arrived back in Adelaide.

The War Years and After

The expedition was home, but for Mawson there was to be no respite and it was to be a further six eventful years before he was able to resume an ordered academic life again. The First World War began as he was returning from an overseas business trip to Europe concerned with the wind-down of the expedition, and by 1916, after travelling to the United States, he was back in Britain where he spent the remainder of the war on highly responsible government work with the Ministry for Munitions. He did not return to Adelaide until May 1919. Back at the University he found that little had changed in his absence except that Walter Howchin had been awarded the title of Honorary Professor in Geology and Palaeontology in 1918. Mawson (1944a) wrote later: 'I was not a little confounded. I would have packed up and left immediately but for the supreme consideration of faithfully recording and adequately publishing the immense mass of data received during my Antarctic Expedition'. Early in 1920 he talked with Howchin about the future: 'stating that I was not prepared to continue at Adelaide for another year under the then existing inadequate arrangements for geology'. There was no prospect of the much-needed new building for geology and Mawson tied himself to a compromise twenty year agreement on additional accommodation which proved increasingly inadequate as years went by, and which he was later to regret. Meanwhile, Howchin's continuing presence at the University was perceived by Mawson as a hindrance to the satisfactory development of the Geology Department and it must have been a great relief to him when Howchin, then 75, decided to retire at the end of the year.

In 1921 Douglas Mawson was appointed to the newly created Chair of Geology and Mineralogy, and Dr Cecil Madigan, his old comrade from the Antarctic, joined him as Lecturer the following year. Mawson and Madigan were to be the only two staff members in the Geology department for much of the inter-war period. The establishment of the new department and his teaching and administrative duties (not to mention continuing Antarctic matters) took precedence in the early 1920s but field investigations were resumed in both the Olary region and the north Flinders Ranges. While he built on his work in the Boolcomatta area, locating several key sections spanning the junction between the basement and overlying sedimentary sequence, he was never to resume a sustained fieldwork program in the region, despite the urgings of David.

David's retirement at the end of 1923 and the politics involved in choosing his successor proved unsettling for Mawson who at that time was still not fully committed to staying in Adelaide and applied for the job, and although the best qualified of the candidates, he was ultimately unsuccessful because of David's influence on the course of events and his (perhaps over-zealous) loyalty and support to Leo Cotton, his deputy and locum for many years, who was appointed to the Chair. The outcome certainly posed strains on the David-Mawson relationship, and further tensions and distractions were to follow when David's increasing obsession with the search for supposed Precambrian fossils focussed on the old rocks in South Australia (see also p124, End of an Era). On an earlier visit to Adelaide in 1921, David had found what he believed to be arthropod remains in the old rocks at Reynella (long considered by Howchin as Early Cambrian) tentatively placing them in the late Precambrian (Proterozoic) and proposing a new division—the *Adelaide Series*.

Meanwhile, Mawson turned his attention to the north Flinders once again. He had published a brief comparison of the Mount Painter and Olary provinces (Mawson 1912b), but the results of his investigations around Mount Painter in 1910 were treated more fully in a long-delayed paper (Mawson 1923) in which he recognised a core of

FIGURE 7. The Radium Hill Mine, soon after its discovery. Mawson, 1944b, pl.19. Courtesy Royal Society of South Australia..

FIGURE 8. Mount Gee, viewed from the west. Mawson, 1944b, pl. 19. Courtesy Royal Society of South Australia.

Precambrian igneous and metamorphic rocks overlain by a sedimentary series similar in many respects to those overlying the basement in the Adelaide region. He followed David's lead in applying the term *Adelaidean* (Adelaide Series) to these sediments and suggesting a Proterozoic (late Precambrian) rather than Cambrian age. Igneous activity included two acid phases, the second with pegmatites and aplites followed by a volcanic phase characterised by vesicular basalts. The mineralisation of the Mount Painter-Mount Gee area, notably the quartz reef at Mount Gee and the uranium minerals (torbernite and autunite) at Mount Painter, was described in detail (Fig. 8).

Following Mawson's enthusiastic report on the uranium potential of the area after his initial visit in 1910, several companies had been floated and prospecting carried out on Radium Ridge and Mount Gee. Meanwhile the Mines Department had been more cautious but in favour of further prospecting. Sporadic attempts at developing the prospects (notably the No. 6 workings) had languished during the war, but in 1924 there was renewed interest in radioactive ores world-wide and a return to the Mount Painter field seemed justified. Consequently, Mawson returned north in November 1924 and spent much of his time in the Mount Painter area on detailed study of the mineralised rocks but also in broader scale assessment of the regional context of the mineralisation.

The regional geology of the Flinders Ranges was little known at this time. Howchin had made a pioneer traverse from west to east at the level of the Parachilna Gorge in 1907 but the results were not published until 1922. While on his return trip from the north, Mawson had the good fortune to make a particularly significant discovery just west of the Italowie Gorge. It was a case of the prepared mind recognising the significant evidence and provides a good example of Mawson's versatility as a geologist, for fresh from the mineral riches of the Mount Painter country he was now to show that he had a good eye for a

FIGURE 9. Entering Yudanamutana. Mawson, 1923, pl. 33. Courtesy Royal Society of South Australia.

fossil also. What he found were 'curious markings' on roadside outcrops of limestone which 'on inspection ... was found to be due to massed fossil heads of a *Cryptozoon*-like alga ... developed in a massive formation, the algal remains constituting the bulk of at least some of the beds' (Mawson 1925). Similar structures had been reported from the MacDonnell Ranges by Chewings and described by Howchin (1914) but there was as yet no general agreement on their stratigraphic position. Mawson inclined towards an Early Cambrian age, but David, on hearing of the find thought they might be older (Proterozoic). Very little was then known of Precambrian life forms; most of the obscure remains described being referred to as *Crpytozoon* (hidden life)—but the recently announced discovery of algal fossils in Precambrian rocks in Montana by Walcott suggested that the Flinders rocks might be of similar age. David certainly believed so and urged Mawson to investigate further. Mawson's 'Cryptozoons' are now recognised as algal stromatolites. These columnar and dome-shaped structures produced by the trapping of sedimentary particles by mats of blue-green algae are the earliest abundant fossils and are well developed in certain of the Precambrian rock formations in the Flinders Ranges. Mawson, however, was not to be pressured into narrow specialisation and continued his wide-ranging investigations of Flinders Ranges geology (Figs 9, 10), publishing further papers in the mid 1920s. One was on the volcanic rocks of the Wooltana area (Mawson 1926a), first encountered in Arkaroola Creek in 1910 and subsequently examined near Wooltana on a brief visit in 1924. There he found a thick sequence of volcanics—vesicular lavas, tuffs and agglomerates overlain by boulder beds and finer sediments which he described as: 'most probably of fluvio-glacial and glacial origin'. Large granite boulders higher in the section were even more convincing, leaving: '... no doubt in my mind ... as to the glacial nature

FIGURE 10. The quartzite of the Yudanamutana Gorge. Mawson, 1923, pl. 33. Courtesy Royal Society of South Australia.

of these beds...' Sediments above the glacials, unsuccessfully searched for fossils, were believed of likely Late Precambrian age.

Another spin-off from the 1924 North Flinders trip was a visit to the Paralana Hot Springs which interested Mawson because of the radioactive nature of the waters (Mawson 1927a). For a short period about this time an enterprising doctor had sought to capitalise on the supposed therapeutic qualities of the spring by setting up a spa on the site, although with no success. The springs are situated close to the faulted junction between the old rocks of the ranges and the younger sedimentary basin to the east. While most geologists supported an origin from deep-seated basin waters, Mawson speculated on a possible contribution from the highly uranium-rich rocks lying to the west. He collected water and gas for examination, hoping the latter would prove rich in helium. Unfortunately the samples did not survive the journey back to Adelaide. The highly active gas which at first puzzled the analysts, has since proved to be rich in radon; the water is much less radioactive.

Mawson had made a brief visit to the Willouran Ranges on the north western flank of the Flinders in 1920. From here he described and named the *Willouran Series*—a thick sequence of sandstones, slates and calcareous beds underlying a dominant quartzite formation and forming a synclinal structure (Mawson 1927b). Sediments of probable fluvio-glacial origin were also found in the eastern part of the area.

Mawson's activities in the Flinders Ranges during the 1920s were essentially of a reconnaissance nature and based on relatively little time, overall, spent in the field. The information included in the papers cited above demonstrate how much he could gain from a brief investigation, displaying his strength as a field worker and skill in rapidly appraising the geological situation in unknown country, and revealing his pre-eminence as an explorer-geologist. Work carried out during this period, while not yet part of a coordinated research programme, provided the basis for his later systematic approach to regional studies in the 1930s and 1940s.

Away from his empirical work in the field, he demonstrated a comparable ability to synthesise existing knowledge in a lengthy treatment of the igneous rocks of South Australia, delivered as a Presidential Address at the AAAS meeting at Perth in August 1926 (Mawson 1926b). This was an important review, given the widespread distribution and importance of igneous rocks, notably in the older terrains of the State, but also in those of younger age. By discussing them region-by-region in their structural and stratigraphic context, he produced what was essentially a geology of the State. One issue of particular interest, not to be resolved for many years, was the age of the highly metamorphosed sediments on the eastern flank of the Mount Lofty Ranges and their associated intrusives. With reference to Howchin's view that these rocks were the equivalents of the Adelaide Series, Mawson urged caution, pointing out: 'the geological mapping of the Ranges is yet only in the early stages (and) final conclusions are unsafe until more detailed petrology and complete geological mapping have been accomplished'. As for the Victor Harbor granites Mawson comments perceptively: 'there is yet no convincing evidence against the assumption of an early Palaeozoic age for this granite'.

Central Australia 1927

In November 1927, Mawson and Madigan made a short visit to Alice Springs and the Western McDonnell Ranges to check a mineral occurrence which had excited local interest. A white crystalline substance, long known to the aborigines and which burned with a fierce flame, was thought possibly to have some connection with petroleum. Specimens had been brought to Adelaide (initially to Madigan), and identified by Mawson as potassium nitrate (saltpetre or nitre) a rare mineral with some economic use in the chemical and explosives industries. Realising the opportunity for geological exploration in an area still little known geologically, Mawson quickly organised an expedition to investigate. They travelled north by train to Alice Springs, and their car journey out through the western ranges from Alice Springs blazed a trail through country never traversed by vehicle before. The deposit proved to be of organic origin, the long-time accumulation of animal droppings, of scientific but not economic interest.

Much of the route west ran along the strike of the well-exposed sedimentary beds which gave a general indication of the southward dipping succession between the Precambrian crystalline basement and known Ordovician rocks of the Horn Valley. Traverses were run and rough sections made at several localities along the way, including Ellery Creek, and over 10 000 feet of strata were measured. In the lower beds

'cryptozoal limestones' and organic structures similar to those from the Flinders Ranges were prominent in several areas, while worm tracks and traces of mollusc shells together with algal limestones distinct from those lower in the sequence were found in the younger beds. On the basis of his limited field evidence, the sedimentary sequence was divided into two divisions—the Pataknurra and Pataoorta Series, once again showing his flair for the rapid assessment of the general geological situation in a new area. He made tentative and essentially correct correlations between the central Australian rocks and the older sequences in South Australia. This first and, as it proved, only venture into central Australian geology was a major contribution to knowledge of the region, building on and revising the earlier work of Tate and Watt (on the Horn Expedition), H. Y. L. Brown, C. Chewings and L. K. Ward.

Mawson visited London the following year where he exhibited photographs and specimens at the Geological Society. The results of the expedition were published by the Society (Mawson & Madigan 1930). While circumstances determined that Mawson never returned to the Centre, it seems likely that he always envisaged following up the promising results of his first trip. Madigan, meanwhile, had been captivated by the Centre and immediately began his own independent and wide-ranging researches into the geology of the region which were to produce some of his best work. This perceived 'take-over' by Madigan was resented by Mawson and led to bad feeling between the two men, but Mawson was soon to be occupied with other matters.

BANZARE 1929–31

Mawson was very much involved with Antarctic matters from 1929 through into the early thirties. BANZARE (The British, Australian and New Zealand Antarctic Research Expedition) differed from Mawson's previous expeditions in being ship-based. The program was carried out on two summer cruises (1929–30, 1930–31) and while no land bases were established, limited sorties were made ashore, notably on some of the sub-Antarctic islands. With the emphasis on marine science, much of the data was collected by systematically sounding the depth of the offshore waters, sampling the water column and dredging the bottom for biological specimens. Because of the nature of the expedition, geological work was restricted, although sediments collected from the sea-floor adjacent to the land and the variety of ice-transported boulders dropped there provided abundant evidence of sedimentation and sedimentary processes in a modern glacial environment. The BANZARE expedition further inspired Mawson to continue his study of the ancient glacial deposits in the Flinders Ranges, and he was to do this with renewed vigour in the years ahead.

The extended geographical and geological knowledge of Antarctica resulting from the BANZARE voyages enabled Mawson to be the first to postulate the existence of an extensive landmass lying beneath the southern ice-cap and bounded by a wide continental shelf. Much of the evidence for the geological make-up of this buried continent came from the ocean-floor studies where dredged boulders proved to be rocks of continental type. Mawson envisaged that the mineral resources of Antarctica, the existence of which his expeditions had suggested but were yet to be proven, would be developed at some time in the future, and that underground mining operations could be carried out successfully despite the problems of climate and terrain.

End of an Era

Professor Edgeworth David died in 1934. In his later years he had become increasingly obsessed with his recognition of 'fossils' in the Precambrian rocks of South Australia (David 1928). Most of his finds had been made on visits to Adelaide at times when Mawson was away overseas or otherwise engaged on Antarctic business and had no chance to control these incursions. For Mawson it was particularly galling for David to hint that his old student was sitting on a rich treasure trove of Precambrian fossils while he, David, made the pickings, even enlisting Mawson's students and staff to help him collect. Wisely, Mawson held his counsel and endeavoured not to be drawn into the matter. It soon became clear, to almost all but David, that the supposed 'fossils' were in fact inorganic in origin (a verdict upheld by later workers), but he was to persist in his belief through to the end of his life, considering his discoveries in South Australia to be the highpoint of his career.

Deciphering the Flinders

In the mid-1930s Mawson renewed his long-

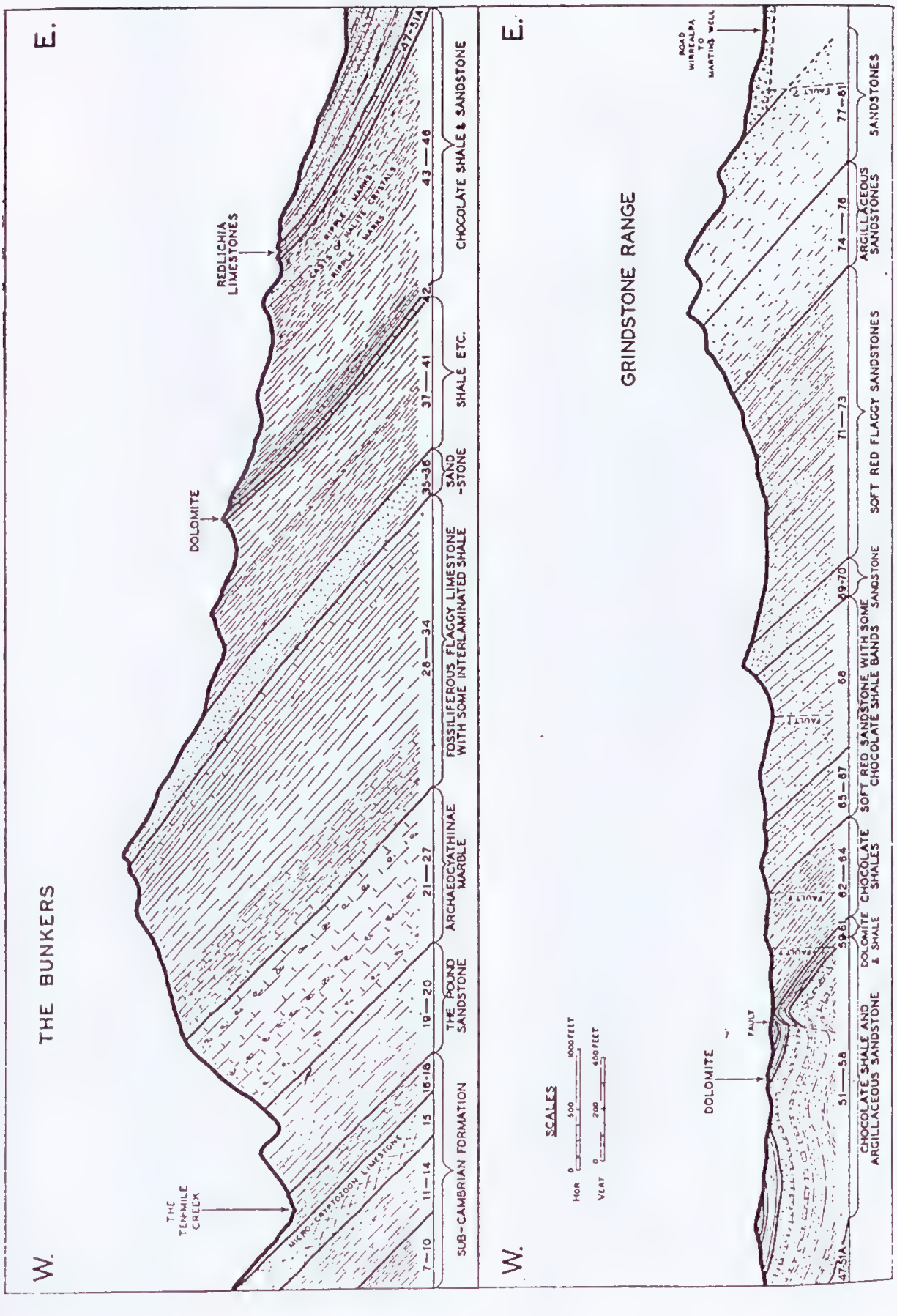
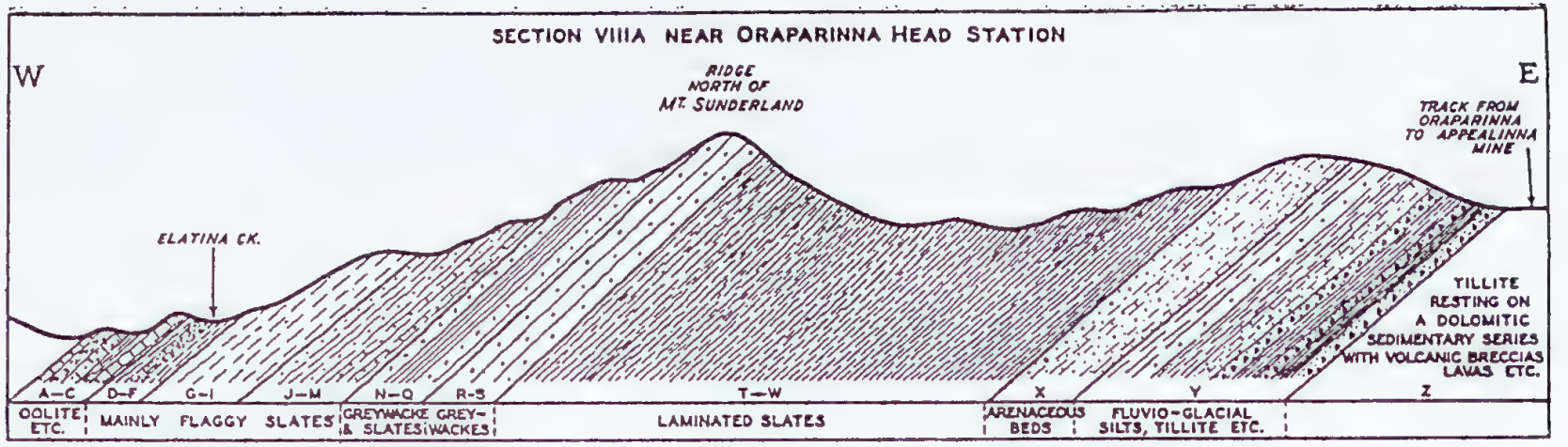


FIGURE 11. Stratigraphic section through the Bunkers and Grindstone Ranges. Mawson, 1939, fig. 2. Courtesy Royal Society of South Australia.



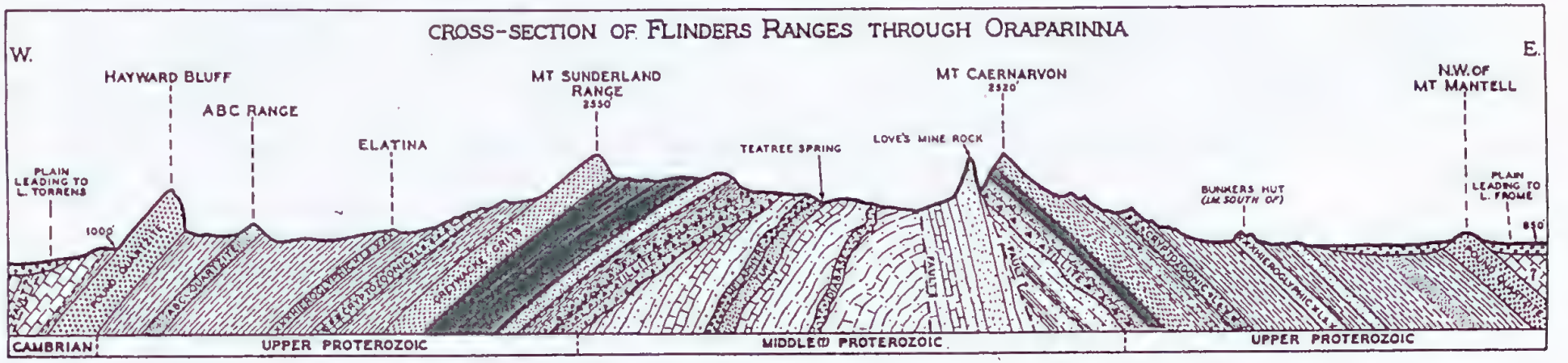


FIGURE 12. Stratigraphic sections near Oraparinna, Flinders Ranges. Mawson, 1942. Courtesy Royal Society of South Australia.

standing but formerly sporadic association with the Flinders Ranges. Now for the first time with fewer distractions, he was able to develop and pursue a sustained and systematic fieldwork program the results of which constitute his most notable contribution to South Australian geology. Only a brief resume of this work is given here, to be treated more fully in a later paper.

The Flinders Ranges were sparsely populated in the 1930s, and moving around in the outback more arduous than today. Roads and tracks were in general poorly maintained and motor transport, then in its infancy, was still an adventurous undertaking. There were no photo-based maps or accurate large-scale topographic maps available in those days, the only maps available being pastoral plans which were quite inadequate as a base for geological mapping. Mawson's approach was to select key sections which were measured and described in detail. In a few of his papers, small-scale regional maps were included. He first used aerial photography as an adjunct to his fieldwork in the late 1940s. Field-camps in the pre- and early war years combined the instruction of senior (third year) students in field techniques, including section measuring, with the gathering of basic geological information in country previously geologically unknown.

By 1939, having spent time in the Wooltana, Mount Carnarvon, Parachilna Gorge and Italowie areas, Mawson's work in the Flinders had reached a stage where review was warranted, and two publications in that year, on the Late Precambrian, and Cambrian successions respectively (Mawson 1939a, 1939b), detail rock sequences in the Brachina Creek-Oraparinna and Wirrealpa Basin areas of the central ranges (Fig. 11). The Pound Quartzite, the dominant ridge-former of the Flinders which occurs some distance stratigraphically below the oldest fossiliferous Cambrian rocks, was provisionally placed at the base of the Cambrian on lithological grounds and interpreted as marking the start of a new cycle of sedimentation. Defining the Precambrian-Cambrian boundary was to become of increasing interest to geologists in the years ahead, a task made no easier by the lack of fossils and by the absence of major breaks in sedimentation in the thick Upper Precambrian to Cambrian sedimentary sequence in South Australia. In his Wirrealpa Basin paper, two important fossiliferous units are described: the *Archaeocyatha Limestone* and a younger limestone (the *Wirrealpa Limestone*) first described by Howchin but here fully documented for the first time with its fossil fauna of algal remains (*Girvanella*), brachiopods (*Obolella*), pteropods and trilobite fragments (*Redlichia*).

Other papers were to follow dealing with sequences in the Aroona, Copley, Brachina and Wilpena areas and culminating in an important review, 'The structural character of the Flinders Ranges' (Mawson 1942), which brought together the results of his fieldwork program to that time. A small scale map (Fig 13) showed the location of the key sections measured and the distribution of the rocks spanning the four main periods of deposition: the Middle Proterozoic and Late Proterozoic, the Cambrian and the Tertiary-Recent. Key marker beds, including the prominent Pound and ABC Quartzites, tillites and hieroglyphic limestones were also delineated. A cross-section (Fig. 12) indicated the essentially simple anticlinal structure of the central ranges. A wider-ranging paper (Mawson 1947) extended and amplified his earlier work, adding new information from the western flank of the ranges both in the north (near Copley) and in Mundallio Creek to the south. In both areas Mawson recognised thick quartzite formations at the base of the sequence, pointing out the error made by Segnit (1939), working for the Mines Department, who had equated these ABC Quartzite sequences with the Pound Quartzite. Mawson, however, was himself misled in the area west of Quorn where he mistook the prominent folded ABC Quartzite as Pound Quartzite (here thinly developed). Such are the dangers of making correlations on lithological grounds in rocks without fossils to act as age indicators.

Mawson also discussed the Flinders succession in its broader tectonic framework which he considered a major trough of deposition of Late Precambrian to Cambrian age and referred to as the 'great synclinal basin' (later to be named the Adelaide Geosyncline). His work had demonstrated the great thickness of strata deposited in the trough which extended south from Central Australia to the Adelaide region and lay between two ancient Precambrian massifs: Yilgarnia to the west and Willyamia to the east. The flat-lying sedimentary cover-rocks to the west of Port Augusta, believed on lithological and structural grounds to be correlates of the basal quartzites in the western ranges are now known to be ABC Range Quartzite equivalents. Wider correlations of the Flinders Ranges succession with the rocks of the western Mount Lofty Ranges (comparisons with the still largely unresolved sequence on the eastern flank of the Mount Lofty

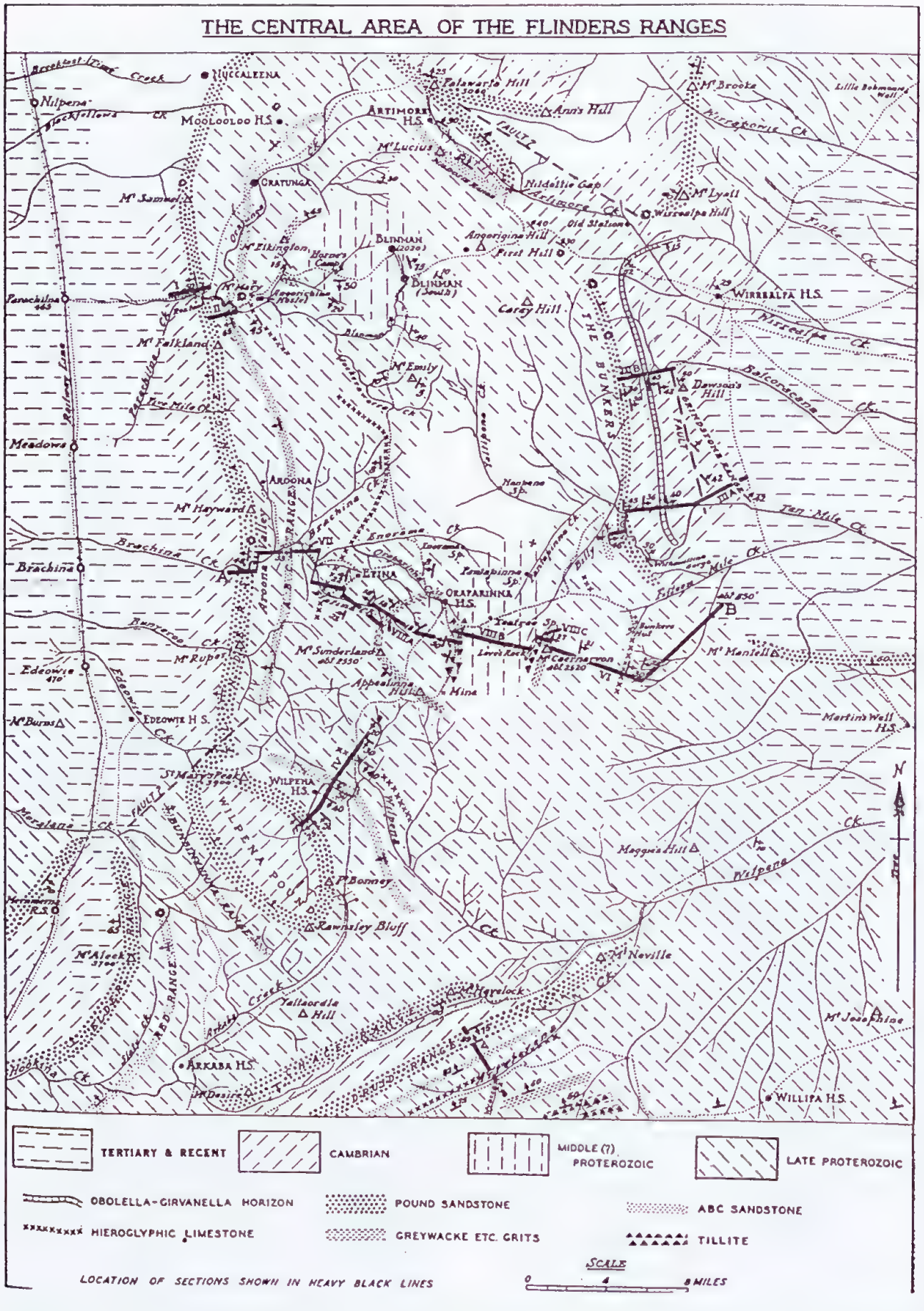


FIGURE 13. Mawson's geological map of the central Flinders Ranges. Mawson, 1942. Courtesy Royal Society of South Australia.

Ranges still remain highly speculative), with Central and Western Australia and also with South Africa (Transvaal System) were also suggested and discussed (Mawson 1947).

In the early 1940s Mawson returned to the North Flinders investigating the metamorphic effects of plug-like granite intrusions in the Precambrian country rocks (Mawson & Dallwitz 1945a,b). This study of both the sedimentary and igneous aspects of the geology of the region linked his early work on the older mineralised terrains in the Mount Painter area with his later concentration on unravelling the stratigraphy of the overlying sedimentary sequence.

Ancient Glaciation

Mawson first encountered evidence of ancient glaciation on his trip to the north Flinders in 1910. Subsequently he had demonstrated the widespread distribution of glacial rocks in the ranges during his extensive field investigations (Fig. 14). His Antarctic experience of a glaciation-in-being, with the diversity of its products and processes, from the coarse boulder beds of terminal moraines to the finely layered sediments laid down in tranquil glacial lakes, had equipped him, as he had intended it should, to recognise the varied and not always easily interpreted evidences for former ice-ages.

By the late 1940s, Mawson had established the stratigraphic position of the Sturt Tillite in many areas of the Flinders and also identified a younger glacial episode in the Elatina area on the western flank of the central ranges (Mawson 1949a). The distinctive sediments—coarse sandy beds overlain by a thick unstratified boulder bed—first encountered in 1938, had initially been thought to be of pyroclastic origin (Mawson 1938) because of the preponderance of igneous pebbles in the rock.

Mawson then produced evidence for a third glacial event, this time predating the Sturt Tillite (Mawson 1949b), in the deeply eroded high

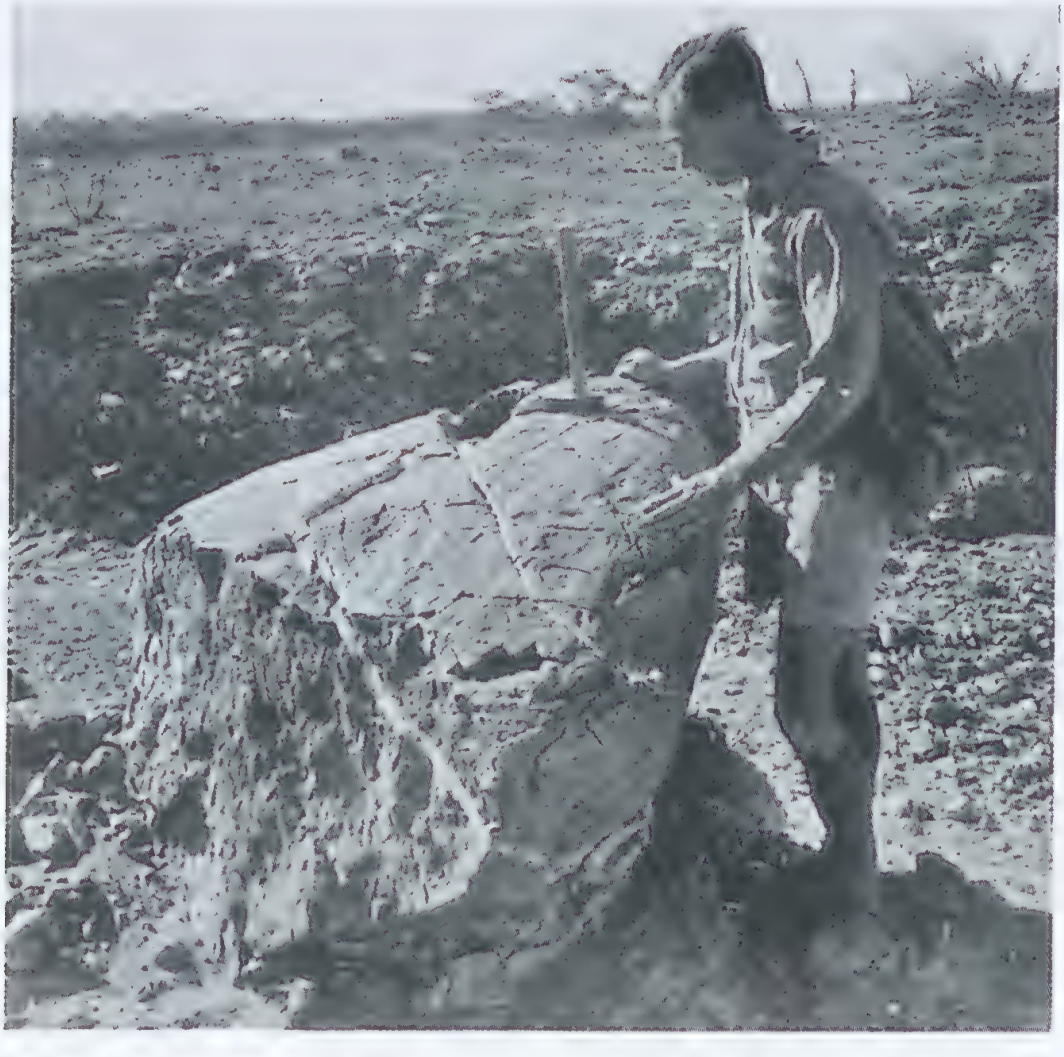


FIGURE 14. A large striated erratic weathered out of Proterozoic tillite, Yankaninna Station. Photo R. H. Jones. Mawson, 1945, pl. 14. Courtesy Royal Society of South Australia.

country of the Bibliando Dome east of Hawker. Here a thick sequence of glacials and associated beds revealed two extended periods of glaciation separated by a well-defined inter-glacial interval. The younger glacial event was equated with the Sturt Tillite while the older (lower) tillites were referred to as the Bibliando stage.

The clear demonstration of a third glacial phase in the history of the geosynclinal basin, with a broad range of deposits from boulder tillites through coarse fluvio-glacial sediments to fine laminated shales, raised such questions as the interpretation of past geographies, climates and environments, and the cyclic nature and causes of glaciation. Mawson, with his deep and extensive knowledge of ice-action both ancient and modern, was, more than any other geologist of his generation, aware of the diversity, complexity and the problems associated with interpreting glacial evidence. He discussed some of these in his paper on Bibliando, which marks the culmination of his career-long investigation of glacial phenomena. He took the opportunity to view this latest work in a broad historical perspective. The early discoveries of Selwyn, Tate and Howchin had placed South Australia at the forefront of research in the study and understanding of past glaciations. His own work had extended and clarified that knowledge, setting it within the wider context of the development of a major Upper Precambrian geosyncline, the importance of which had now become apparent.

While the rocks in the Flinders are magnificently displayed and accessible for study, the lack of fossils in the ancient rocks have always made the task of the stratigrapher difficult. Mawson, the first geologist to systematically approach the task of establishing an ordered succession was acutely aware of this problem. As his work proceeded and became recognised beyond South Australia, he perceived the need for a standardisation of geological nomenclature, particularly of stratigraphic names, and he was a member of the first committee set up by ANZAAS in 1947 which led to a Code of Stratigraphic Nomenclature being formalised in 1950.

Mawson favoured dropping the long-established but restricted Adelaide Series of David and Howchin and replacing it with the Adelaide System which he sub-divided into the Torrensian, Sturtian and Marinoan Series (Mawson & Sprigg 1950). The defining of the Adelaide System marked the end of Mawson's work on the old rocks of South Australia. The discovery of jellyfish fossils by Reg Sprigg in the Pound Quartzite at Ediacara in 1946 (Sprigg, 1947, 1949), and the later finds of a diversified animal fauna by Flounders and Mincham, led to a reappraisal of the stratigraphy of the fossil-bearing beds (Glaessner & Daily 1959). Relegation of the Pound Quartzite from the base of the Cambrian (as previously suggested by Mawson) to the uppermost formation in the Precambrian meant that the Ediacara fossils, now confirmed as the oldest animals known, became world famous.

The South-East

Contrasting strongly with the rugged grandeur of the Flinders Ranges, the geologically youthful and topographically unchallenging south-eastern region of South Australia attracted Mawson from the mid-1930s. He became interested in the problematic 'coorongite', a rubbery bituminous substance first discovered in 1852 at Alf Flat east of Salt Creek at the southern end of the Coorong Lagoon (Fig. 15). A belief that the flammable material might be a petroleum product led to speculation that oil existed at depth; and several (unsuccessful) drilling attempts were made in the 1880s and again in the 1920s. By then almost all investigators had become convinced of the vegetable origin of the substance (and it has since been shown to be the product of algal blooms). Mawson, however, was unconvinced; and he inadvertently attracted overseas interest for a brief period when he took a visiting petroleum expert from Britain (Washington Gray) into the field to view the material and Gray went home to publicise the find, much to Mawson's chagrin. Some biochemical work was carried out overseas on the 'algal gel', but the matter was not pursued any further.

More substantial and fruitful work in the region led to a series of publications on the small and isolated outcrops of granitic rock which protrude through the thin Quaternary cover of the Upper Southeast. Fieldwork involved exploration on a minor scale, for many of the outcrops lay in difficult country accessible only on foot or horseback and where the outcrops were not extensive. The studies were carried out in association with students or former students and covered a quadrilateral bounded by Meningie and Coonalpyn on the north and Kingston and Bordertown to the south. The field investigations and subsequent analytical work led Mawson to recognise a variety of intrusive and extrusive rock

FIGURE 15. Mawson, with auger, drilling for coorongite, the Coorong, mid-1930s. Washington Gray on right. Source unknown.

types in the outcropping basement: granites; adamellites and granodiorites; and quartz keratophyres (volcanic). Similarities between the intrusives of the South-East and those occurring along the eastern flank of the Mount Lofty Ranges and on Kangaroo Island supported the concept of a large granitic batholith existing beneath the sedimentary cover, and, on the available evidence, Middle to Late Cambrian in age.

Finale

Mawson was sixty-three at the end of the Second World War and approaching the normal age for retirement. He continued on, however, to the age of seventy and spent his last university years rounding off his own researches and ensuring that his department was left in a healthy and secure position to meet the challenges ahead.

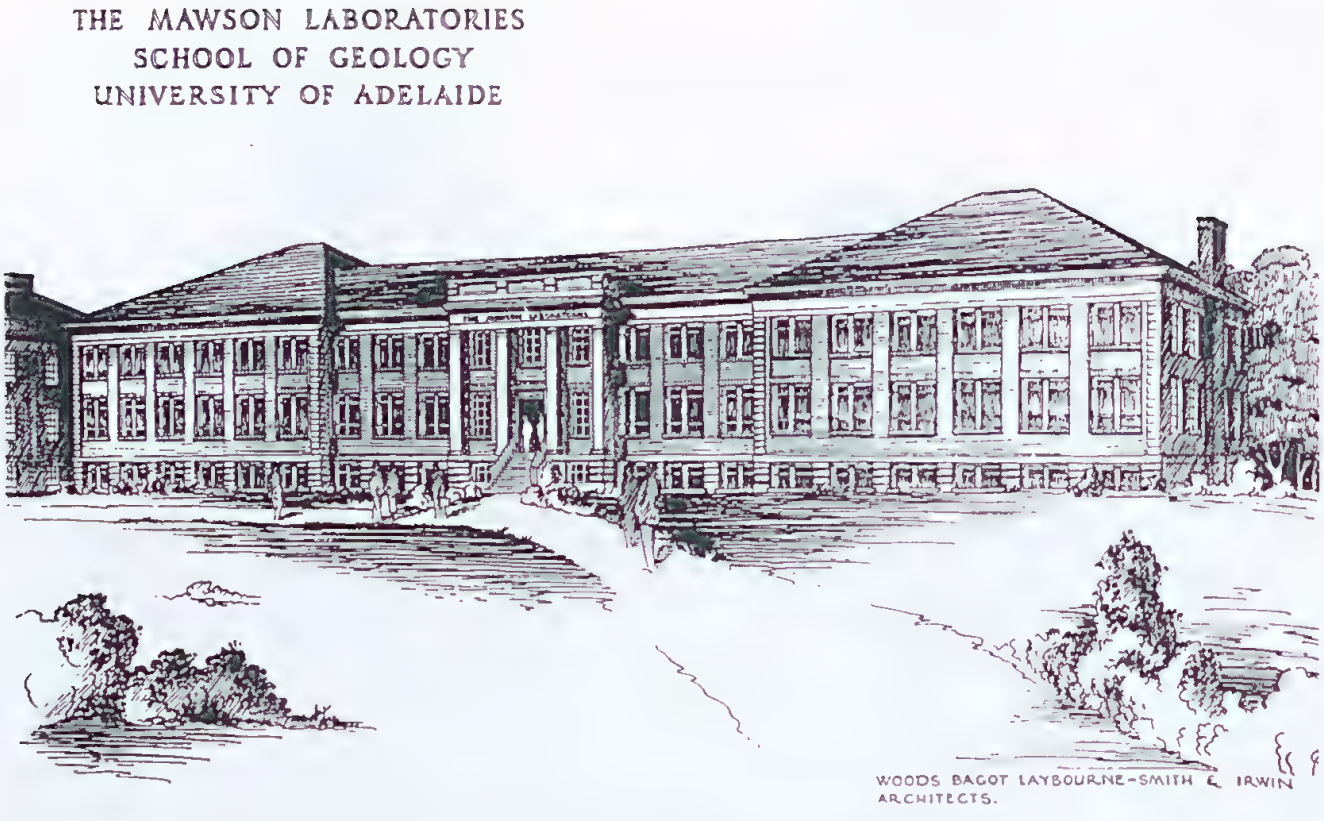


FIGURE 16. The proposed Mawson Laboratories. Courtesy Woods Bagot Pty Ltd, Adelaide.

He had been acutely aware of the greatly increased role that geology would be required to play in the post-war world. In particular, well trained geologists could only be supplied by the universities which in turn would need to provide a sufficient level of support in terms of accommodation, equipment and staffing. In all these areas Mawson had been struggling against inadequacies for over twenty years. During this time, geology had made the best of sub-standard accommodation and increasingly inadequate provision for research, whereas the rest of the University had developed and prospered. It was the urgent need for a better deal for geology that prompted his memorandum to the University authorities in February (1944a). In his memorandum Mawson wrote: 'The department suffers from insufficiency of room, from inadequacy of the laboratories, and from the entire absence of any planned layout suitable for a science department. All other science departments of the University now have buildings specially planned for their needs though some are already proving too limited in accommodation for the flood of students now presenting themselves. Ours is an anachronism'.

He went on to make a very strong case for the role of geology in education, its application to national development and significantly, South Australia's importance as a source of future mineral resources. He envisaged Adelaide University as a future centre for teaching and research in economic and mining geology and itemised the basic needs of a modern School of Geological Studies, estimating the cost of the new development at around £25 000.

His argument was decisive. The University responded appropriately, if belatedly, and the Mawson Laboratories were constructed, largely to his specifications, between 1949 and 1952 (Fig. 16). He just had time to move into the new building before retirement. By then his staff had increased to five and included E. A. Rudd who was appointed to the new Chair of Economic Geology in 1949, and Martin Glaessner, a palaeontologist with an international reputation who was to become the authority on the Precambrian fossils from Ediacara. Arthur Alderman, former student and junior lecturer in the department, returned after a period away from the University to take over from Mawson as Professor of Geology and Mineralogy in 1953.

In the years following his retirement Mawson remained active and influential in Antarctic matters and continued his long association with the South Australian Museum as Honorary

Curator of Minerals and Member of the Museum Board. He was appointed Chairman of the Board in 1952.

Douglas Mawson's broad interests in all aspects of geological science and his unfailing encouragement and support of young people with an enquiring mind and an interest in science is well illustrated by the background to his last published paper (Mawson 1958). It deals with australites (small glassy objects of meteoritic origin) collected by a young schoolboy, Mervyn Pens, from the Murray Plains west of Morgan in the mid-1930s. Mawson had visited the site and established a correspondence with young Pens, which led to further finds and ultimately to the public aquisition of a large and significant collection of australites now housed in the South Australian Museum. The paper was read before the Royal Society of South Australia on 10 October 1957. Sir Douglas Mawson died on 14 October 1958.

Mawson's Legacy

Mawson's inborn qualities as an explorer, his methodical approach to the job in hand, his tenacity and resolution and an ability to inspire and motivate others were revealed as much in his career as an academic geologist as in his exploits as an Antarctic explorer. He was essentially a man of action, a trail-blazer, single-minded in the pursuit of his goals, at times impatient for results, and who could, at times, be protective to the point of touchiness, of his own areas of interest. His inherited characteristics, hard-headed Yorkshire practicality, stubborness and reticence, with a streak of romanticism (from his father) were blended with a pioneer Australian belief in opportunity and self-reliance to produce a complex character of contrasting and at times conflicting elements. He was a man not easily assessed or categorised. Geology is arguably the most adventurous of all the field sciences (the first scientist to visit the moon was a geologist), and Mawson in his life and career, both in the Antarctic and in his geological investigations in outback South Australia, exemplified both the scientific-explorer and explorer-scientist.

Mawson's scientific career spanned, almost exactly, the first half of the twentieth century. When he entered the University of Sydney in 1899 the scientific world-view was of a cooling, shrinking earth not more than one hundred million years old, the limits having been set by the physicists. Geologists, whose investigations had by then spread to all parts of the globe, intuitively sensed a more ancient earth but lacked the means to prove it. Mountain belts were seen as a crustal adjustment to a cooling interior and most geologists accepted the relative permanence of the continents and oceans.

In retrospect, the years 1900–1950 can be viewed as a relatively quiet episode in the development of geological science, enlivened by two developments early in the century : the application of the discovery of radioactivity to the dating of rocks, and Wegener's hypothesis of continental drift. Each in its own time, the first rapidly, the second much more slowly, became a vital element in the future Plate Tectonic revolution. The recognition that the decay of radioactive minerals produced heat freed geologists from the shackles of a cooling earth and a restricted time-scale by providing a source of self-sustaining energy and a means of dating the crustal rocks. By 1914, the estimated age of the earth had been pushed back to over one thousand million years. Mawson's work on radioactive minerals in Australia as a young student and his later discoveries in South Australia gave him a pioneer role in this new development and he was always very proud of his work in this field (see Mawson 1944b). But in his day Australia was effectively too remote from the rest of the world for its small and largely inaccessible deposits to be economically viable, and its universities (certainly Adelaide) too poor to engage in expensive age-dating equipment. In his later years Mawson was keenly interested in these developments overseas and their future potential for dating the old rocks in Australia.

Communication between scientists was severely curtailed during the two world wars which dominated the first half of the century, although technical developments during the second war were to help revolutionise geological and geophysical exploration both on land and in the ocean basins. Mawson's own career was savagely disrupted by the First World War and his more active years were over before the benefits of post-Second World War technical advances became widely felt. The inter-war years and those immediately after the second war were his most productive period for research, more particularly from the mid-1930s when his active involvement in Antarctic exploration had ended. Although the general outline of South Australian geology was well known by this time, no systematic work had been attempted and for much of the State

information remained highly generalised and lacking in detail. As previously indicated, Mawson's early researches were essentially exploratory reconnaissances, becoming more systematic with his work in the Flinders from the 1930s. His detailed descriptions of rock units and measured cross-sections of key sequences provided the basis for the regional mapping program to be instigated by the Geological Survey in the 1960s.

Mawson's research was very much an integral part of the growth and development of his department. His field studies in the Flinders were carried out with small groups of advanced students as part of their course work, while in the Southeast he published in collaboration with post-graduate and former students as well as directing them in projects of their own. His teaching is remembered by past students as being of variable quality; he was at his best, according to Alderman, when extemporising on subjects that particularly interested him. There is no doubt that he could inspire his students and a considerable number went on to make distinguished careers in geology and mineralogy, among them E. A. Rudd, L. W. Parkin, R. C. Sprigg, W. B. Dallwitz, D. E. Thomas, E. R. Segnit, B. Skinner, R. L. Crocker, M. Reynolds, B. Daily, R. Sweatman, A. Kleeman, B. Forbes and G. Chinner.

Mawson, the man of action, always seemed to have been fighting a lack of time to complete his projects; always planning another field trip and, one senses, chafing at the administrative burden placed on him as a highly responsible and consistently conscientious head of department. Never an armchair geologist, Mawson did not have the time or the inclination to become involved with the theoretical issues of the day, the most contentious of which was the idea of continental drift. Sir Mark Oliphant, a science student at the University in the 1920s, has recalled attending a debate on the subject between Mawson and Wood-Jones the anatomist, during which Mawson scathingly dismissed the concept of drift, citing the rigidity of the ocean floors and the lack of any known mechanism that could power the process.

Sir Douglas Mawson made an outstanding contribution to South Australian geology. His list of 102 publications, the majority published in the *Transactions of the Royal Society of South Australia*, provide the material evidence of his work. He also left a strong department which he had established and which was developing rapidly in teaching and research. While it is idle to speculate, one cannot help but wonder what he might have accomplished as a geologist if so much of his time and energy had not been devoted to the Antarctic. He was not able to settle down to an ordered academic life and an on-going research program until he reached his fifties. From then on his geological output was sustained until the end of his career. It was a remarkable achievement.

Acknowledgments

The research on which this paper is based was begun when the author was a staff member in the Mawson Graduate Centre for Environmental Studies at the University of Adelaide and completed as an Honorary Research Associate at the South Australian Museum. It relies heavily on a study of the Mawson Papers housed in the Special Collections archive of the Barr Smith Library, The University of Adelaide, and Mawson's published papers. Research was also carried out on the Edgeworth David papers held by the Fisher Library at the University of Sydney and in the library of the Scott Polar Research Institute, Cambridge.

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Selected Bibliography of Douglas Mawson

(See Alderman (1959) for a Memoir and Bibliography of Mawson. Innes and Duff (1990) give a complete list of his scientific and other papers together with biographical works on Mawson).

1903 (with T. G. TAYLOR). The geology of Mittagong. *Journal and Proceedings of the Royal Society of New South Wales* **37**: 306–350.

1904 (with T. H. LABY). Preliminary observations on radioactivity and the occurrence of radium in Australian minerals. *Journal and Proceedings of the Royal Society of New South Wales* **38**: 382–389.

1905 The geology of the New Hebrides. *Proceedings of the Linnean Society of New South Wales* **3**: 400–485.

1906 On certain new mineral species associated with carnotite in the radioactive orebody near Olary. *Transactions of the Royal Society of South Australia* **30**: 188–193.

1912a Geological investigations in the Broken Hill area. *Memoir of the Royal Society of South Australia* **2**(4): 211–319.

1912b PreCambrian areas in the north-eastern portion of South Australia and the Barrier, New South Wales. *Reports of the Australasian Association for the Advancement of Science* **13**: 188–191.

1915 *The Home of the Blizzard*. Heinemann, London. [Extracts quoted are taken from the abridged popular edition (Hodder – Stoughton 1930), published as a facsimile edition by the Wakefield Press, 1996.]

1923 Igneous rocks of the Mount Painter belt. *Transactions of the Royal Society of South Australia* **47**: 376–387.

1925 Evidence and indications of algal contributions in the Cambrian and Pre-Cambrian limestones of South Australia. *Transactions of the Royal Society of South Australia* **49**: 186–190.

1926a Wooltana basic igneous belt. *Transactions of the Royal Society of South Australia* **50**: 192–200.

1926b A brief resume of present knowledge relating to the igneous rocks of South Australia. *Reports of the Australasian Association for the Advancement of Science* **18**: 229–274

1927a The Paralana hot spring. *Transactions of the Royal Society of South Australia* **51**: 391–397.

1927b Geological notes on the area along the north-eastern margin of the north-eastern portion of the Willouran Range. *Transactions of the Royal Society of South Australia* **51**: 386–390.

1930 (with C. T. MADIGAN). The pre-Ordovician rocks of the McDonnell Ranges, Central Australia. *Quarterly Journal of the Geological Society of London* **86**: 415–428.

1938 The Mount Carnarvon Series of Proterozoic Age. *Transactions of the Royal Society of South Australia* **62**: 347–351.

1939a The Cambrian sequence in the Wirrealpa Basin. *Transactions of the Royal Society of South Australia* **63**(2): 331–347.

1939b The late Proterozoic sediments of South Australia. *Reports of the Australasian and New Zealand Association for the Advancement of Science* **24**: 80–88.

1942 The structural character of the Flinders Ranges. *Transactions of the Royal Society of South Australia* **66**(2): 262–272.

1944a Unpublished memorandum on housing the department of geology, The University of Adelaide. February 1944.

1944b The nature and occurrence of uraniferous mineral deposits in South Australia. *Transactions of the Royal Society of South Australia* **68**(2): 334–357.

1945a (with W. B. DALLWITZ). The soda-rich leucogranite cupolas of Umberatana. *Transactions of the Royal Society of South Australia* **69**(1): 22–49.

1945b (with W. B. DALLWITZ). Scapolitised dolomites of Yankaninna. *Transactions of the Royal Society of South Australia* **69**(2): 212–216.

1947 The Adelaide Series as developed along the western margin of the Flinders Ranges. *Transactions of the Royal Society of South Australia* **71**(2): 259–280.

1949a The Elatina glaciation: a third recurrence of glaciation evidenced in the Adelaide System. *Transactions of the Royal Society of South Australia* **73**: 117–121.

1949b The late Precambrian ice-age and glacial record of the Bibliando Dome. *Journal and Proceedings of the Royal Society of New South Wales* **82**: 150–174.

1950 (with R. C. SPRIGG). Subdivision of the Adelaide System. *Australian Journal of Science* **13**(3): 69–70.

1958 Australites in the vicinity of Florieton, South Australia. *Transactions of the Royal Society of South Australia* **81**: 161–163.

References

ALDERMAN, A. R. 1959. Professor Sir Douglas Mawson – Memoir and Bibliography. *Transactions of the Royal Society of South Australia* **82**: 1–6.

ALDERMAN, A. R. 1967. The development of geology in South Australia. *Records of the Australian Academy of Science* **1**(2): 30–52.

BICKEL, L. 1977. *This Accursed Land*. Macmillan Australia.

CORBETT, D. W., COOPER, B. J. & MOONEY, P. M. 1986. 'Geology' *in* 'Ideas and Endeavours – the Natural Sciences in South Australia'. *Royal Society of South Australia Occasional Publication* Number **5**.

DAVID, T. W. E. (with R. HELMS & E. F. PITTMAN) 1901. Geological notes on Kosciusko, with special reference to evidences of glacial action. *Proceedings of the Linnean Society of New South Wales* **26**: 26–74.

DAVID, T. W. E. & PRIESTLEY, R. 1914. Geology Vol. 1. Reports on the Scientific Investigations, the British Antarctic Expedition, 1907–08.

DAVID, T. W. E. 1928. Notes on the newly-discovered fossils in the Adelaide Series (Lipalian?), South Australia. *Transactions of the Royal Society of South Australia* **52**: 191–209.

DAVID, T. W. E. & TILLYARD, R. J. 1936. Memoir on fossils of the late Pre-Cambrian (Newer Proterozoic) from the Adelaide Series, South Australia. Angus and Robertson, Sydney.

FERRAR, H. T. 1907. Report on the field geology of the region explored during the 'Discovery' Antarctic Expedition, 1901–04. *National Antarctic Expedition 1901–04, Natural History, I, Geology (Field Geology: Petrography).* British Museum, London.

GLAESSNER, M. F. & DAILY, B. 1959. The geology of the late Precambrian fauna of the Ediacara Fossil Reserve. *Records of the South Australian Museum* **13**(3): 369–401.

HOWCHIN, W. 1897. On the occurrence of Lower Cambrian fossils in the Mount Lofty Ranges. *Transactions of the Royal Society of South Australia* **20**(2): 74–86.

HOWCHIN, W. 1901. Preliminary note on the existence of glacial beds of Cambrian age in South Australia. *Transactions of the Royal Society of South Australia* **25**: 10–13.

HOWCHIN, W. 1914. The occurrence of the Genus *Cryptozoon* in the ? Cambrian of Australia. *Transactions of the Royal Society of South Australia* **38**: 1–10.

HOWCHIN, W. 1922. A geological traverse of the Flinders Range from the Parachilna Gorge to the Lake Frome Plains. *Transactions of the Royal Society of South Australia* **46**: 46–82.

INNES, M. & DUFF, H. 1990. 'Mawson's Papers'. The Mawson Institute for Antarctic Research, The University of Adelaide.

JACKA, F. 1986. Mawson, Sir Douglas(1882–1958). Australian Dictionary of Biography **10**: 454–457.

MAWSON, P. 1962. 'Mawson of the Antarctic'. Longmans, London.

PARER, P. & PARER-COOK, E. 1983. 'Douglas Mawson the Explorer'. Alella Books ABC.

SEGNIT, R. W. 1939. 'The Pre-Cambrian Cambrian Succession'. *Bulletin of the Geological Survey of South Australia* **18**.

SHACKLETON, E. 1911. 'The Heart of the Antarctic'. Heinemann, London.

SPRIGG, R. C. 1947. Early Cambrian (?) jellyfishes from the Flinders Ranges, South Australia. *Transactions of the Royal Society of South Australia* **72**(2): 212–224.

SPRIGG, R. C. 1949. Early Cambrian 'Jellyfishes' of Ediacara, South Australia. *Transactions of the Royal Society of South Australia* **73**: 72–99.

SPRIGG, R. C. 1986. The Adelaide Geosyncline: a century of controversy. *Earth Sciences History* **5**(1): 66–83.

REVISION OF AUSTRALIAN *ENOCHRUS* THOMSON (COLEOPTERA: HYDROPHILIDAE)

C. H. S. WATTS

WATTS, C. H. S. 1998. Revision of Australian *Enochrus* Thomson (Coleoptera: Hydrophilidae). *Records of the South Australian Museum* **30**(2): 137–156.

The Australian members of the hydrophilid genus *Enochrus* are revised and redescribed. A key to the fourteen species recognised is given. Six species are described as new: *E. aliciae, E. eubenangeei, E. isabellae, E. pseudoweiri, E. samae,* and *E. weiri*. The following synonymies are proposed: *E. mjobergi* Knisch, 1921 = *E. deserticola* (Blackburn, 1896); *E. andersoni* (Blackburn, 1896) = *E. eyrensis* (Blackburn, 1894); *E. persimilis* Régimbart, 1908 = *E. eyrensis* (Blackburn, 1894); *E. pullus* (Fauvel, 1883) = *E. esuriens* (Walker, 1858) and *E. artensis* (Fauvel, 1883) = *E. maculiceps* (MacLeay, 1873). The New Caledonian species *E. caledonicus* (Fauvel, 1883) is considered a synonym of *E. elongatus* (MacLeay, 1873).

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The hydrophilid genus *Enochrus* Thomson, 1859 is world wide in distribution (Hansen 1991). In Australia its members are the commonest and most widespread hydrophilids and occur in virtually all fresh water bodies from small stagnant pools to the banks of major rivers and lakes. Despite this prominence, their taxonomy is so bad that no species can be identified with any confidence. Thirteen species have been named and several others have been recorded as being present but until now no revision has been attempted.

Australian *Enochrus* are structurally very similar and difficult to separate. Apart from the aedeagi the only characters that I have found useful are size, the punctation of the upper surface, the slope of the mesosternal keel, and the colour pattern of the head. The colour pattern of the head is often a reasonable indicator of species, whereas elytral and pronotal colour can vary from predominantly black to totally light reddish in the same species.

Within *Enochrus* six subgenera are recognised (Hansen 1990). Three of these occur in Australia: *Hydatotrephis* MacLeay, 1873 with one species; *Enochrus* Thomson, 1859 with one species; and *Methydrus* Rey, 1885 with 12 species.

At first sight *E.* (*H.*) *mastersi* is very similar to the distantly related *Limnoxenus zealandicus* Broun and is often confused with it in collections. Both are moderate sized (10–15 mm), shiny black and relatively common, particularly *L. zealandicus*. A closer inspection readily separates them: *L. zealandicus* has well defined punctate elytral striae and swimming hairs on the meso- and meta-tibiae, both of which are absent in *E. (H.) mastersi*. Characters of the maxillary palpi and mesosternum also separate the two genera (Hansen 1990).

The one Australian *Enochrus (Enochrus)* species, *E. (E.) peregrinus* Knisch, 1922, is small and in general appearance resembles several Australian *Enochrus (Methydrus)* species. It is known from only one specimen labelled from Sydney, although there were three in the original collection. It may eventually prove to have been mis-labelled and not Australian.

The remaining 12 Australian species are all in the subgenus *Methydrus*. They are usually small (2–8 mm), oval, rather flat species, shiny with light-testaceous to black colouring with at least the area immediately in front of the eyes yellowish. Two species are larger and predominantly black, superficially resembling *E. (H.) mastersi*. *Chasmogenus nitescens* Fauvel resembles some *Enochrus (Methydrus)* species and is often confused with it in collections. Its small size (< 5 mm) and lack of yellowish areas in front of its eyes readily separate it from similar sized *Enochrus* – as well as many structural characters mentioned later under 'Systematics'.

One additional species, *Philhydrus marmoratus* W. MacLeay, 1873, has been included in *Enochrus* in the past but has been shown by Gentili, 1981 to belong in *Laccobius*.

For a full discussion of synonyms and subgenera of *Enochrus* see Hansen, 1991.

Despite their being ubiquitous in freshwater the biology of Australian *Enochrus* is poorly known.

Anderson (1976) described the larvae of *E. (M.) maculiceps* and *E. (M.) elongatus* and gave brief notes on their habitat and breeding. All species come readily to light and are often collected in large numbers in light traps, particularly in northern areas during the wet season from December to February. I know of no study of the ecology of any Australian species other than inclusion in general faunal lists of invertebrates collected in various water bodies.

The collections from which specimens were examined are listed under the following abbreviations:

AM	Australian Museum, Sydney
ANIC	Australian National Insect Collection
BM(NH)	Natural History Museum, London
IRSNB	Institut Royal des Sciences Naturelles de Belgique, Bruxelles
MNHN	Muséum National d'Histoire Naturelle, Paris
NMV	Museum of Victoria
NRS	Naturhistoriska Riksmuseet, Stockholm
NTM	Northern Territory Museum
QDPIM	Queensland Department of Primary Industries, Mareeba
QM	Queensland Museum, Brisbane
SAMA	South Australian Museum, Adelaide
UQIC	University of Queensland Insect Collection, Brisbane
WAM	Western Australian Museum, Perth.

Systematics

Australian members of the genus *Enochrus* can be separated from other Australian Hydrophilids by the following combination of characters. Length 2–9 mm, oval, more flattened than convex; second segment of maxillary palpi more or less curved outwards, apical segment slightly asymmetrical with straighter inner face; without contiguous ventral keel but with variable keel on mesosternum; without swimming hairs on tibiae; without strongly marked striae on elytron; with systematic punctures (rows or fields of coarse setiferous punctures usually distinctly larger than others) on head and pronotum (masked in some *E. malabarensis*); in all but *E. mastersi* and *E. aliciae* at least the area immediately in front of eyes lighter (see also Hansen 1991).

The subgenus *Hydatotrephis* MacLeay can be separated from Australian members of the subgenera *Enochrus* Thomson and *Methydrus* Rey as follows: mesosternal protuberance triangular, cone-shaped, abruptly truncated posteriorly which does not reach the front edge of mesocoxae (Fig. 19), sides of mesosternum evenly converging anteriorly, apical and penultimate segments of maxillary palpi subequal. *Enochrus (Methydrus)* have a more keel-like mesosternal process usually extending backwards between the mesocoxae (Figs 15–18; 20), the apical segment of the maxillary palpi shorter than penultimate and sides of mesosternum subparallel to strongly convex anteriorly. Apart from *E. (M.) aliciae* and *E. (M.) eubenangeei*, the Australian members of *E. (Methydrus)* are smaller (< 8 mm), often testaceous in colour, and have at least a lighter patch of colour in front of the eyes.

The aedeagus of *E. (H.) mastersi* differs from that of other Australian *Enochrus* (Fig. 14; Hansen 1990). In these there is a variably shaped basal ventral plate beyond which projects a thinner apical portion in all but *E. (M.) aliciae* which lacks this apical portion (Fig. 11). In *E. (H.) mastersi* the aedeagus is of more uniform construction with a smooth dorsal surface and the ventral surface consists of a broad open groove formed by infolding of the two sides.

There is one species, *E. (E.) peregrinus* Knisch, of the subgenus *Enochrus* in Australia. It is similar in looks to the smaller *Methydrus* species but is readily separated from them by the short stout maxillary palpi with approximately equal sized apical two segments and the diverging elytral suture lines.

By utilising the male genitalia species can be differentiated. However without these I have found it impossible to reliably separate all species, in particular *E. weiri* and *E. pseudoweiri* and the lighter colour phase of *E. deserticola* and *E. maculipes*. This is reflected in the keys and descriptions that follow. I have restricted my descriptions to the few characters that serve to differentiate the species and I have provided two keys, one utilising all available characters, the other characters other than the male genitalia.

Key to Australian *Enochrus* Thomson 1859, not using characters of the male genitalia

1. — Maxillary palpi stout, first segment shorter than distance from front edge of eye to front of clypeus, apical segment subequal in length to penultimate 2
— Maxillary palpi more elongate, first segment

longer than distance from front edge of eye to front margin of clypeus, apical segment about 2/3 length of penultimate (subgenus *Methydrus*) 3

2. — > 6.0 mm. Black. Sutural lines on elytra subparallel in anterior quarter .... *E.* (*Hydatotrephis) mastersi* (MacLeay)
— < 5.0 mm. Dark testaceous. Sutural lines on elytra diverging noticeably in anterior quarter .. .. *E.* (*Enochrus) peregrinus* Knisch

3. — Large (>6 mm). Black (pronotum may be reddish at edges) 4
— Small (< 6 mm). With at least the areas in front of eyes reddish-yellow 5

4. — Punctures towards sides of elytra well impressed, not much smaller than others .... *E. (M.) eubenangeei* sp. nov.
— Punctures towards sides of elytra subobsolete, much smaller than those on disc .... *E. (M.) aliciae* sp. nov.

5. — Dorsal surface reddish-yellow, rear of head at most somewhat darker. Elytra moderately punctate, length > 4.0 mm, pro-, meso- and metaclaws modified in male. .... *E. (M.) elongatus* (W. MacLeay)
— Dorsal surface reddish-yellow to black, rear of head dark and much of rest of head in many species, males with only pro-claws modified 6

6. — Dorsal surface strongly punctured, punctures on elytra as strong or stronger than those on head, many punctures on elytra >half diameter of serial punctures which are often hard to trace. Front of head 1/3 or more black 7
— Dorsal surface weakly punctured, punctures on elytra tend to be weaker than those on head, punctures on elytra < half size of serial punctures which are usually distinct 9

7. — Length >3.5 mm. Black morphs present. Maxillary palpi with dark tips 8
— Length < 4.0 mm. Black morphs not known. Maxillary palpi usually pale throughout .... *E. (E.) malabarensis* Régimbart

8. — Thinner outer portion of mesosternal keel well developed (Fig. 16). Front of head predominantly black .... *E. (M.) eyrensis* (Blackburn)
— Thinner outer portion of mesosternal keel less developed (Fig. 15). Amount of black on front of head variable ..... *E. (M.) samae* sp. nov.

9. — Length 2.2 mm – 2.6 mm. Mesosternal keel weakly developed (Fig. 18). Front of head > 2/3 black ..... *E. (M.) esuriens* (Walker)
— Length > 2.6 mm. Mesosternal keel well developed (Fig. 17) 10

10. — Larger (4.5–6 mm). Black, except region in front of eyes light. Elytral punctures small but usually well marked .... *E. (M.) isabellae* sp. nov.
— Smaller (3–4.5 mm) *E. (M.) deserticola* complex (*E. (M.) deserticola* (Blackburn), *E. (M.) maculiceps* (W. MacLeay), *E. (M.) weiri* sp. nov and *E. (M.) pseudoweiri* sp. nov). (*E. (M.) deserticola* only species with black morphs and individuals > 4.2 mm long. *Enochrus weiri* and *E. pseudoweiri* always have pale palpi.)

Key to Australian *Enochrus* incorporating characters of the male genitalia

1. — Maxillary palpi stout, pseudo first segment shorter than distance from front edge of eye to front of clypeus, apical and penultimate segments subequal in length 2
— Maxillary palpi more elongate, pseudo first segment longer than distance from front edge of eye to front margin of clypeus, apical segment noticeably shorter than penultimate (subgenus *Methydrus*) 3

2. — > 6.0 mm. Black. Sutural lines on elytra subparallel in anterior quarter .... *E. (Hydatotrephis) mastersi* (MacLeay)
— < 5.0 mm. Dark testaceous. Sutural lines on elytra noticeably diverging in anterior quarter .. .. *E. (Enochrus) peregrinus* Knisch

3. — Large (> 6.0 mm). Black (pronotum may be reddish at edges) 4
— Small (< 6.0 mm). With at least the areas in front of eyes reddish-yellow 5

4. — Aedeagus broad reaching little beyond half length of parameres (Fig. 11). Parameres flat... ..... *E. (M.) aliciae* sp. nov.
— Aedeagus with broad basal piece and long thin apical piece bending upwards and reaching nearly to end of parameres, which also bend upwards (Fig. 10) .... *E. (M.) eubenangeei* sp. nov.

5. — Tips of parameres hooked (e.g. Fig. 4) 6
— Tips of parameres not hooked (e.g. Fig. 1) 9

6. — Dorsal surface reddish-yellow, rear of head at most somewhat darker. Aedeagus tip strongly crotchet-shaped (Fig. 7). Pro-, meso- and metaclaws modified in male .... *E. (M.) elongatus* (W. MacLeay)
— Variably coloured but always with rear of head clearly darker than at least portions of front of head. Aedeagus with little or no dorsal/ventral expansion at tip, males with only proclaws modified 7

7. — Dorsal surface strongly punctured, many punctures on elytra > half size of serial punctures ..... *E. (M.) eyrensis* (Blackburn)
— Dorsal surface weakly punctured, punctures on elytra < half size of serial punctures 8

8. — Larger (4.5 – 6.0 mm). Black, except in front of eyes. Aedeagus shorter and apical portion broader (Fig. 6) ..... *E. (M.) isabellae* sp. nov.
— Smaller (3.0–4.0 mm). Pale morphs common. Aedeagus longer and apical portion thinner (Fig. 4) ..... *E. (M.) deserticola* (Blackburn)

9. — Length <2.8 mm. Front of head ≥ 2/3 black. Mesosternal keel weak (Fig. 18) ..... *E. (M.) esuriens* (Walker)
— Not as above 10

10. — Dorsal surface strongly punctured, punctures on elytra as strong as, or stronger than, those on head, many punctures on elytra > half diameter of serial punctures 11
— Dorsal surface weakly punctured, punctures on elytra tend to be weaker than those on head, punctures on elytra < half size of serial punctures 12

11. — Larger (4.4–5.6 mm). Black morphs present. Aedeagus with moderate apical pad, inner edges of parameres sinuate (Fig. 9) ..... *E. (M.) samae* sp. nov.
— Smaller (<3.8 mm). No black morphs. Aedeagus narrow with, at most, a weak pad, inner edges of parameres straight (Fig. 12) ..... *E. (M.) malabarensis* Régimbart

12. — Tips of parameres truncated or weakly bifid (Fig. 8) ..... *E. (M.) weiri* sp. nov.
— Tips of parameres rounded (Figs 1, 2, 3) 13

13. — Aedeagus moderately broad with slight to well-marked apical pad (Figs 1, 2) ..... *E. (M.) maculiceps* (W. MacLeay)
— Aedeagus narrow, sharply pointed, lacking apical pad (Fig. 3) ..... *E. (M.) pseudoweiri* sp. nov.

Descriptions

Subgenus *Enochrus*

Enochrus* (*Enochrus*) *peregrinus Knisch, 1922

Types

Lectotype: ♀ 'Sidney Mus. Godeffroy No. 10705, coll. Knisch, coll. d'Orchymont'; 'ex. col. Knisch, No. 5251438, coll. d'Orchymont'; 'Knisch det. 1921, *Enochrus peregrinus* m'; 'Coll. A. Knisch, TYPUS', on red card, in IRSNB, herein designated.

Knisch (1922) mentioned three specimens (No. 10705) in the Hamburg Zoological Museum. I have been able to trace only one. He mentioned that one was labelled 'M. Régimbart det. 1905' and the others with 'Wehncke determ'. The surviving specimen, now in Brussels, lacks such a label but would otherwise appear to be part of the syntype series.

Description (number examined, 1)

Length 3.2 mm. Broadly oval. Elytra dark-testaceous, pronotum very slightly lighter, head black except for small indistinct testaceous patch along margin in front of each eye, maxillary palpi light-testaceous, tips darker. Punctures on head moderate, approaching size of eye facet, most separated from each other by at least puncture width. Systematic punctures rather sparse, about twice diameter of adjacent punctures. Pronotum rather weakly and sparsely punctured, serial punctures also relatively small, indistinct, about 2x diameter of adjacent punctures, punctures on elytra stronger than on pronotum, sparse, many 2x diameter or more apart, a little stronger laterally. Serial punctures not traceable. Maxillary palpi short, stout, pseudo basal segment not reaching front edge of eye, apical and penultimate segment subequal in size.

Male: Unknown.

Distribution

Known only from Sydney, the type locality.

Remarks

This unique specimen is separated from all other Australian *Enochrus*, other than the much larger *E. mastersi*, by the short stout maxillary palpi. The masking of the elytral strial punctures is found only in the much larger *E. eyrensis* and *E. samae* and in *E. malabarensis*. *Enochrus malabarensis* differs from *E. peregrinus* by the more normal (for Australian species) maxillary palpi, the more extensive testaceous areas in front of the eyes and lighter coloured elytra. The elytral sutures continue to diverge noticeably in anterior quarter whereas in *E. malabarensis* they are subparallel. Most *E. malabarensis* also have stronger punctures, but this character is variable and tends to be relatively weak in the few Sydney area specimens I have seen. The pronotal punctures in *E. peregrinus* are weaker than those on elytra whereas in *E. malabarensis* they are similar sized.

The fact that only the type specimen is known worries me. For all the other small Australian *Enochrus*, specimens are relatively abundant. Also it is the only known specimen in the Australian region of the subgenus *Enochrus* (Hansen 1990). This is the sort of situation where mislabelling should be considered. This is beyond the scope of this revision.

Subgenus *Hydatotrephis*

Enochrus (Hydatotrephis) mastersi (MacLeay)

Hydatotrephis mastersi MacLeay, 1871

= *Farana simplex* Knisch, 1922: Hansen, 1990

Enochrus (Hydatotrephis) mastersi (MacLeay): Hansen, 1990

Types

Hydatotrephis mastersi: Lectotype: (♀), (round red label), 'K 19501', '*Hydatotrephis mastersi* Mc L.W. Gayndah'. *'Lectotype: Hydatotrephis mastersi* W. J. MacLeay designated by M. Hansen 1990', AM.

Farana simplex: Lectotype: (unsexed) 'Sidney Mus. Godeffroy. No. 10704'; '*Philhydrus* x M. Régimbart determ. 1905'; '*Farana simplex* Knisch n.g. et sp. A. Knisch det. 1921', round black label; 'Lectotype *Farana simplex* Knisch designated by M. Hansen 1988', IRSNB. Synonymy after Hansen 1990.

Description (number examined, 71) Figs 14, 19

Size 8.0 mm – 9.1 mm. Broadly oval. Relatively flat. Black; lateral edges of elytra, pronotum and head, palpi and apical portions of legs diffusely dark-testaceous. Maxillary palpi stout, length about width of head in front of eyes, apical and penultimate segments subequal in length, together a little larger than pseudo first segment. Head strongly punctured, each about size of eye facet, most closer than a puncture width apart, systematic punctures 2–3x size of normal punctures. Pronotum with punctures a little smaller, shallower and more separated than on head, systematic punctures well marked, with sharp groove sometimes weak or lacking on front edge. Elytra punctured as on pronotum, each elytron with four rows of larger serial punctures, punctures in rows increasing in both number and scatter towards sides, elytra weakly grooved and flanged laterally, a few scattered large punctures between puncture rows two and three counting from suture. Mesosternal keel cone-like, strongly raised, narrowly triangular from both lateral and front views, sharply truncated behind just prior to mesocoxal cavities so that no part of the keel extends between mesocoxae.

Male: Aedeagus broad, lacking collar or ventral plate, sides folded in ventrally tending to form broad channel. Parameres stout, broad, narrowing shortly before tips which tend to be turned inward to varying degrees.

Distribution

Australian Capital Territory

Black Mt, ANIC; Canberra, SAMA, ANIC; 3 km E Piccadilly Circus, ANIC; 6 km NE Piccadilly Circus, ANIC.

New South Wales

Allyn River, ANIC; Barrington River, ANIC; Blue Mts, ANIC Chichester St Forrest, ANIC; Coffs Harbour UQIC; Como, ANIC; Galston, SAMA; Lansdowne via Taree, ANIC; Muswellbrook, ANIC; Nerringa, SAMA; 12 km NW Nellinger, ANIC; 2km NE by N Rousmill, ANIC; Salisbury UQIC; Stanwell Park UQIC; Sydney, SAMA, ANIC; Tooloom Plateau via Woodenbong UQIC; Ulladulla, ANIC; Valery, ANIC; Wee Jasper, ANIC.

Northern Territory

30 ml W Alice Springs, SAMA; Stanley Chasm, SAMA.

Queensland

Brisbane UQIC; Bulburin State Forest via Many Peaks UQIC; Bunya Mt, ANIC; Carnarvon UQIC; Discot, ANIC; 13 km SW by S Gordonvale, ANIC; Joalah Nt Pk Tamborine Mt, ANIC; Mt Norman, via Wallangarra UQIC; Mt Spec, ANIC; Upper Cedar Ck, via Sandford UQIC; 8 km E Wallaman Falls, SAMA.

Victoria

Bagots Ck, SAMA; Ferntree Gully UQIC; Healesville, SAMA; 10 mls N of Valencia Creek via Maffra UQIC; Victorian Alps, SAMA.

Remarks

A widespread and relatively common species which, within Australian *Enochrus*, can only be confused with *E. aliciae* and *E. eubenangeei*. It is readily separated from these species by the stout maxillary palpi which have the last two segments subequal instead of having the apical segment about two-thirds the length of the penultimate as

in all other Australian *Enochrus*. The cone-like shape of the mesosternal keel is also diagnostic.

Enochrus mastersi is most frequently confused with a very different, but similar looking and very common species, *Limnoxenus zealandicus*, of the subtribe Hydrobiina. Although very similar in general appearance *Limnoxenus* can be separated from *E. mastersi* by the presence of nine well-marked series of punctures on each elytron, swimming hairs on the meso- and metatarsi and virtual absence of rugose portions on meso- and metafemora.

Subgenus *Methydrus*

Enochrus (Methydrus) aliciae sp. nov.

Types

Holotype: ♂, '15°16'S, 144°59'E, 14 km W by N of Hope Vale Mission, Qld, 8–10 Oct. 1980, T. Weir', ANIC.

Paratypes: 13, same data as holotype, 10 ANIC, 3 SAMA; 1, '12°31'S, 132°54'E, 9 km N by E of Mudginbarry Hs., N.T., 10.vi.1973, T. Weir and A. Allwood, '13985'', NTM.

Description (number examined, 17) Figs 11, 20

Length 7.5 mm – 8.2 mm. Broadly oval, relatively flat. Shiny, black, appendages, apical and lateral edges of head, pronotum and elytra dark-reddish. Maxillary palpi moderately long, pseudo first segment longer than distance from eye to front of clypeus, longer than maxillary stipe, apical segment $^{2}/_{3}$ to $^{3}/_{4}$ length of penultimate. Head strongly punctate, punctures about puncture width apart, about size of eye facet or a little smaller. Systematic punctures large about 3x size of adjacent punctures. Punctures on pronotum similar to or a little weaker than those on head, systematic punctures well marked, 3–4x diameter of adjacent punctures, rear and lateral margins weakly grooved and flanged, front margin grooved to about level of inner edge of eyes. Elytral punctures as on pronotum, more weakly impressed towards rear. Serial punctures in four loose rows, sparse and indistinct, more numerous but more scattered laterally, elytra weakly grooved and flanged laterally. Mesosternal pillar well marked, triangular in both front and lateral views, posterior edge often steeper near top of keel, reaching a short distance between mesocoxae.

Male: Aedeagus very short, broad, rounded, lacking narrower apical section. Parameres squat, inner edge a little sinuate, tips obliquely truncated on inside or curved weakly outwards. Proclaw straightened with strong basal swelling, mesoclaw thickened, curved with basal swelling, metaclaw straightened and greatly swollen in basal half. In female claws similar but with straightening and basal swelling much weaker.

Distribution

Known only from the type localities in North Queensland and the Northern Territory.

Remarks

Readily separated from all other Australian *Enochrus (Methydrus)*, other than *E. eubenangeei*, by its large size and almost all-black colouring. The very short, broad aedeagus, and weak lateral punctures on the elytra separate it from the otherwise very similar *E. eubenangeei*.

In general appearance it is similar to *E. (H.) mastersi* but readily separated by its longer maxillary palpi with the apical segment shorter than penultimate. See also under remarks in *E. mastersi*.

Enochrus (Methydrus) deserticola (Blackburn)

Philhydrus deserticola Blackburn, 1896

Enochrus (Lumetus) deserticola (Blackburn): Knisch 1924

=*Enochrus mjobergi* Knisch, 1921: syn. nov.

=*Enochrus (Lumetus) mjobergi* Knisch: Knisch 1924

=*Philhydrus temporalis* Régimbart, 1908: syn. nov.

=*Enochrus (Lumetus) temporalis* (Régimbart): Knisch 1924

Types

Enochrus deserticola: Lectotype: '5487, Bl. Paisley T' top specimen of two separately carded on same pin, BM(NH), herein designated.

Paralectotypes: 1 unlabelled but mounted below lectotype on same pin, BM(NH); 1 ♂ '5487 Palm Cr', '*Philhydrus deserticola* Blackb. Co-type', SAMA; 3, 'Reedy Hole', NMV; 2, 'Ellery Ck', NMV; 2, 'Paisley Bluff', NMV.

Enochrus mjöbergi: Lectotype: ♂ 'Cape York Penins'; 'Queensl. Mjöberg'; 'Type', '*Enochrus (Lum.) mjobergi* m. n. sp., A. Knisch 1921'; 'Typus', on red label NRS, herein designated.

Paralectotypes: 1, 'Queensl. Mjöberg Cape York Penins'; 'Sjöstedt don 1921'; 'Ex Coll. Knisch No. 5521544 Coll. d'Orchym'; 'Knis det

Enochrus (L.) mjobergi m'; Coll. A. Knisch TYPUS', on red card. IRSNB; 3, 'Cape York Penins'; 'Queensl. Mjöberg', NRS. Synonymy after examination of types.

Enochrus temporalis: Holotype: 'Avon R'; 'eaudouce'; '*Philhydrus temporalis*, Reg. TYPUS', MNHN. Synonymy based on descriptions and examination of types (of *E. temporalis* in 1964, not currently available).

Description (number examined, >1000) Fig. 4

Oblong oval, length 3.3 mm – 4.9 mm. Two colour morphs; one with dorsal surface black except light portions in front of eyes, other with elytra and pronotum light testaceous and head dark testaceous to black except for light testaceous area forward from eyes and a little wider than eyes, leaving central darker panel of variable width on front of head, underside dark testaceous, appendages lighter towards extremities except for maxillary palpi which usually have apical portion of last segment darker. Head covered with small, sharply impressed, well separated punctures a lot smaller than eye facets, a group of large punctures inwards from each eye, at least 4x diameter of other punctures. Punctures on pronotum as on head, but more shallowly impressed, systematic punctures as in *E. elongatus*, four or more times diameter of adjacent punctures. Elytral punctures increase somewhat in strength apically and laterally, serial punctures large, sparse and quite distinct at apex, interstrial punctures varying from weak to almost obsolete.

Mesosternal keel well developed, front edge nearly perpendicular, ventral edge straight or slightly convex.

Male: Aedeagus pointed, with weak dorsal pad at tip, collar a bit closer to tip than base. Parameres outwardly hooked at tips. Proclaw with basal lobe and rest of claw somewhat straightened. Meso- and metaclaws, with slight basal lobes, weakly curved.

Female: Claws only slightly weaker than males.

Distribution

New South Wales

Bonville, ANIC; Chichester SF, ANIC; Clarence River, NMV; Coff's Harbour, ANIC; Fowlers Gap, ANIC; 10 km N Jabiru, QDPIM; Lord Howe Island, SAMA; Moree, SAMA; Valery, ANIC; Wootton, ANIC.

Northern Territory

Adelaide River, ANIC; E Alligator River, AM; Bessie Spring, ANIC; Berry Spring, ANIC; 45 km SW by S Borroloola, ANIC; 7 km NW by N Mt Cahill Crossing East Alligator River, ANIC; 8 km N Mt Cahill, SAMA; 12 km NNW Mt Cahill, SAMA; 14 km S by W Cape Crawford, ANIC; Cooper Creek, ANIC; Daly River Mission, ANIC; 170 km E Daly Waters, SAMA; Darwin, ANIC, SAMA; Ellery Ck, NMV; 15 km S Elliot, SAMA; Harst Bluff, NMV; 12 km NE Humpty Doo, QDPIM; Jim Jim Creek, ANIC; Koogarra, ANIC; 4 km N McArthur R Stn, SAMA; 19 km SSE Mataranka, SAMA; 5 km E Mataranka, SAMA; Nourlangie Creek, ANIC;18 km E by N Oenpelli, ANIC; Paisley Bluff, NMV; Pine Creek, QDPIM; Reedy Hole, NMV; 46 km S Renner Springs, SAMA; Stanley Chasm, SAMA, ANIC; 100 km W Tennant Creek, QDPIM; Tindal, ANIC; Wessel Island, ANIC.

Queensland

Ashmore, QM; Atherton, ANIC, QDPIM; 31 km NE Aramac, SAMA; Bakerville, QDPIM; Bamaga, SAMA; Brisbane, QM, UQIC; Benaraby, ANIC; 5 mls N Bloomfield River, ANIC; Bundaberg, ANIC; Bunya Mts, ANIC; Burketown, QM; Cairns, ANIC, SAMA; Calliope River, ANIC; Camooweal, QDPIM; Cape Tribulation, ANIC; Cardstone, ANIC; Chillagoe Creek, ANIC, QDPIM; Coen, QDPIM; 60 km S Coen, SAMA; Mt Coolum, ANIC; Cooktown, ANIC; 30 mls N Cooktown, UQIC; Crystal Creek, ANIC; Cunningham's Gap, ANIC; Dalhunty River, SAMA; Edungalba, ANIC; 5 km NE Edungalba, SAMA; Eidsvold, ANIC; Emu Park, UQIC; Fletcher, QM; Gayndah, UQIC; Mt Garnet, ANIC; Greenhills, ANIC; Home Hill, QDPIM; Ingham, ANIC, SAMA; Mt Inkerman, ANIC; Iron Rng, QDPIM; Julatten, ANIC; Julia Creek, SAMA; Kenilworth SF, UQIC; Kingaroy, ANIC; Kuranda, ANIC, SAMA; Laura, QDPIM; 70 km N Laura, QDPIM; 25 km N Laura, QDPIM; Mt Lewis, ANIC; Mackay, ANIC; Magnetic Isl, SAMA; Malanda, SAMA; 23 km E Mareeba, QDPIM; Mary Creek, ANIC; Melvor, ANIC; 21 mls S Miriam Vale, ANIC; 100 mls S Miriam Vale, UQIC; Mission Beach, ANIC; 3 mls W Mourilyan, ANIC; Mornington Isl mission, SAMA; 5 km W Mossman, QM; Mossman George Nt Pk., UQIC; Mossman George, ANIC; Normanton, QDPIM; Oxley Ck, QM; Paluma Dam, ANIC; 9 km W Paluma, QDPIM; Prince of Wales Isl, NMV; 8 mls NE Proserpine, ANIC; Rocklea, QM; Stanthorpe, QM; Mt Spec, ANIC; Stewart Rng, SAMA; Tolga, SAMA; Townsville, ANIC, NMV, SAMA; 9 km ENE Mt Tozer, ANIC; Weipa, QDPIM;

Windsor Tableland, QDPIM; Yamba, UQIC; Yungaburra, QDPIM.

South Australia

Arkaba Creek, SAMA; Mambray Creek, SAMA; Marne River., SAMA; Mt Remarkable, SAMA; 6 km E Nilpinna, SAMA.

Victoria

Dimboola, ANIC; Genoa, ANIC; Sea Lake, SAMA.

Western Australia

6 km NNW Broome, ANIC; Beverley Springs, WAM; Cadjeput Rockhole, WAM; Charnley River, 25 miles N Beverley Springs, WAM; Derby, SAMA; Drysdale River, ANIC; 7 miles NE Giles, WAM; Gill Pinnacle, WAM; Hammesley Rng, SAMA; Koolan Island, WAM; 6.5 km N Mt Bell, WAM; Kununurra, ANIC, QDPIM; Millstream, ANIC; 5 km SE Millstream HS., ANIC; Mitchell Plateau, ANIC; West Peewah River, ANIC; Synnott Range, WAM; 14°53'S, 125°45'E, SAMA.

Remarks

A relatively large species showing considerable variation in size, colour and strength of dorsal punctation making its identification difficult without dissection. The two colour morphs are well marked and occur together in the same populations. Occasional specimens have an intermediate dark-testaceous dorsal surface to a variable extent. It is my impression that the dark form is more common in the north where it is the dominant form in many areas. The black morphs are readily identified by their weak to moderate punctation contrasting markedly with the strong punctation in the two other species with black morphs, *E. eyrensis* and *E. samae*. It is also the only species with the combination of tips of the parameres hooked, weak to moderate dorsal punctures and black patterning on the head. In the North-east the species overlaps with *E. weiri* and *E. pseudoweiri*. These can be separated from most *E. deserticola* by the lack of black morphs, somewhat stronger punctation, pale tips to the maxillary palpi and the small amount of black on the front of the head. An occasional specimen of *E. deserticola* may also have pale palpi tips and much reduced black on the front of the head.

Over most of its range *E. deserticola* is sympatric with *E. maculiceps*. The two species are readily separated by the male genitalia and presence of black morphs in *E. deserticola*. I have, however, been unable to reliably separate light coloured females. In general *E. deserticola* are larger and more weakly punctured but considerable character overlap occurs between the two species.

In more southern areas *E. deserticola* overlaps with *E. eyrensis*, *E. samae* and *E. elongatus* but can be separated from all three by the much weaker punctation and in the case of *E. elongatus* by the well-marked dark patterning on the head which *E. elongatus* lacks.

Enochrus (Methydrus) elongatus (W. MacLeay)

Philhydrus elongatus W. MacLeay, 1873

Enochrus (Lumetus) elongatus (W. MacLeay) Knisch, 1924

= *Philhydrus caledonicus* Fauvel, 1883: syn. nov.

= *Enochrus caledonicus* (Fauvel): Knisch, 1924

Types

Enochrus elongatus: Lectotype: '*Philhydrus elongatus* Gayndah McL W'; 'K19506'. Right-hand specimen of two mounted on same card, AM herein designated.

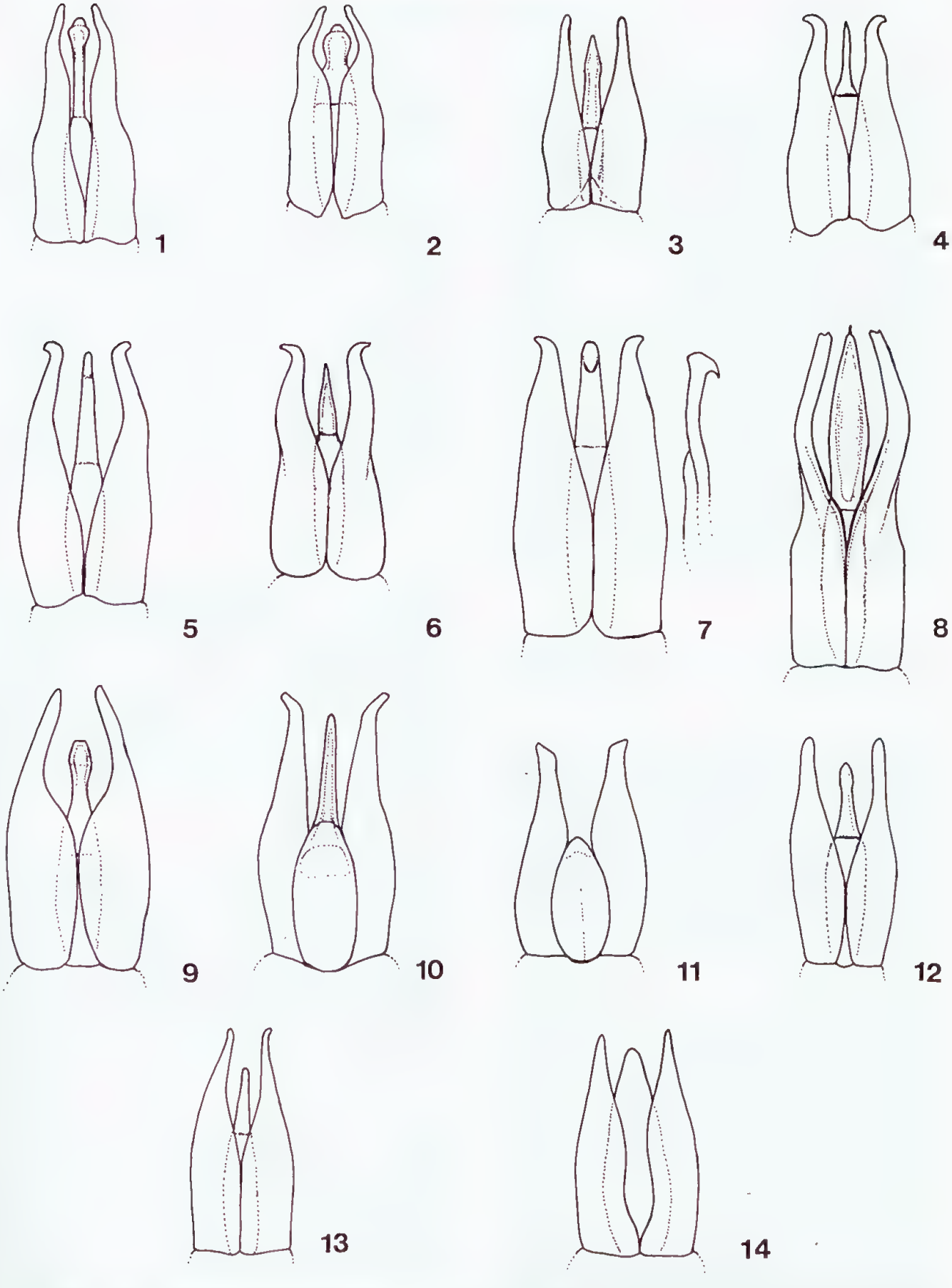
Paralectotypes: 1, same data as lectotype, left-hand specimen, AM; 3, on same card, same data as lectotype, ANIC; 1, '*Philhydrus elongatus* McL', 'Griffith Collection Id by A. M. Lea', 'Co-Type', SAMA; 1, '*Philhydrus elongatus* M. Queensland cotype 14629', SAMA.

Enochrus caledonicus: *Lectotype:* 'm', 'Nouvelle Caledonie. Noumea Marais Anse Vata, Octobre Savés, ex. coll. Fauvel', 'Coll. et det. A. Fauvel *Philhydrus caledonicus* Fvl', '17–479', 'lectotype' on red label. Remounted with genitalia dissected out, IRSNB.

Paralectotypes: 1, 'Nouvelle Caledonie Kanala, Rec. Coste, ex coll. Fauvel'; 'Coll. et det A. Fauvel *Philhydrus caledonicus* Fvl.' '17–479', 1, 'Nouvelle Caledonie. Anse Vata, Nouméa Savés', 'Coll. et det A. Fauvel *Philhydrus caledonicus* Fvl,' IRSNB. Synonymy after examination of types.

Description (number examined, 330) Fig. 7

Elongate oval, body flattish, length 4.4 mm – 5.0 mm. Dorsal surface testaceous, diffusely blotched, lighter towards sides, rear of head often diffusely darker but never distinctly darker than rest of head. Ventral surface dark red-brown, apical portions of legs lighter, palpi light testaceous, tips of maxillary palpi dark brown. Head covered with small sharply impressed, well



FIGURES 1–14. Dorsal views of apical portion of male genitalia. **1** & **2**, *E. maculiceps* showing range of variation; **3**, *E. pseudoweiri*; **4**, *E. deserticola*; **5**, *E. eyrensis*; **6**, *E. isabellae*; **7**, *E. elongatus*, lateral view of median lobe; **8**, *E. weiri*; **9**, *E. samae*; **10**, *E. eubenangeei*; **11**, *E. aliciae*; **12**, *E. malabarensis*; **13**, *E. esuriens*; **14**, *E. mastersi*.

separated punctures, quarter to half size of eye facet, a dozen or so much larger punctures inwards from each eye. Pronotum similarly punctate, a row of systematic punctures about 3x diameter of adjacent punctures running inwards from each front corner and smaller group of similar punctures a little behind middle on each side. Elytral punctures slightly stronger than those on pronotum, stronger laterally than on disc. Serial punctures, larger, sparse, hard to trace towards apex. Underside evenly setose-punctate, rugose portions of femur, approximately three quarters length of femur. Mesosternal keel well developed, anterior edge curved somewhat, nearly perpendicular, ventral edge flat or slightly convex. Notch on apical sternite small but well marked.

Male: Aedeagus with crotchet-shaped hook at tip. Tips of parameres outwardly hooked. Metaclaws with enlarged basal lobe and rest of claw straightened. Pro- and mesoclaws curved with thickened basal portion

Female: Claws curved with thickened basal portions.

Distribution

Australian Capital Territory

Black Mt, ANIC.

New South Wales

Albury, ANIC; Allyn River, NMV; Armadale, ANIC; Balranald, ANIC; Bathurst, AM; Bogan River, AM; 20 mls SSW Bourke, SAMA; Broken Hill, SAMA; Coonabarabran, AM, ANIC; Cowra, AM; Ecceleston, AM; Hay, ANIC; 37 km E Hay, SAMA; Mt Kaputar Nat. Pk., ANIC; Kosciusko Nt Pk., ANIC; Lake Menindie, SAMA; Menindie, SAMA; Narrabri, ANIC; Norfolk Island, ANIC; 97 km S Tibooburra, NMV.

Northern Territory

53 km NE Alice Springs, ANIC; 12 km SW by W Alice Springs, ANIC; Top of Ayers Rock, WAM; 97 km N Barrow Ck, SAMA; 30 km NE by E Borroloola, ANIC; Ellery Creek, NMV; Finke, SAMA; Glen Helen, NMV; Stanley Chasm, ANIC; 15 km East, Vaughan Spring, HS, ANIC.

Queensland

Bollon Dist, AM; 42 km Boulia, ANIC; Bunya Mts, UQIC; Camooweal, QDPIM; Edgbaston HS, SAMA; 5 km NE Edungalba, SAMA; Glen Alpin, UQIC; Helidon, UQIC; 6 km E, Kamma, ANIC; Mackay, ANIC; MacPherson Rng, Nt Pk., AM; Marmor, ANIC; Mt Isa, QDPIM; Mt Spec, ANIC; Normanton, QDPIM; Tolga, QDPIM; Toowoomba, UQIC.

South Australia

Aroona Dam, SAMA; Mt Barr, ANIC; Old Billa Kallina HS, SAMA; Blanche Cup Spring, AM; Broken Hill, AM; Coopers Creek, SAMA; Coward Sp., SAMA; 16 km E Curdimurka, SAMA; 36 km ESE Curdimurka, ANIC; 11 km NE by Etadunna HS, ANIC; Gawler Rngs, SAMA; Lake George, ANIC; Mt Lofty Rng, AM; Mannum, SAMA; Marne River, SAMA, McDovall Peak, UQIC; Murray Bridge, AM, SAMA; Olary, ANIC; Oodnadatta, SAMA; Paralana Hot Springs, SAMA; Quorn, AM; Renmark, SAMA; Roonka Stn, SAMA; Roseworthy, SAMA; Scorpion Springs CP, SAMA; River Torrens, SAMA; Warburton, River, ANIC; Wearing Gorge, SAMA; Willochra Ck, SAMA.

Tasmania

15 m N Waratah, UQIC.

Victoria

Eppalock Res., NMV; Eustace Gap Ck, NMV; King Lake Nt Pk., NMV; Kiata, NMV; La Trobe River, NMV; Lake Hattah, ANIC; Lilydale, SAMA; Little Desert, ANIC; Lake Hattah, NMV; Marysville, SAMA; Melbourne, UQIC; Preston, NMV; Shepparton, ANIC; Skeleton Ck, SAMA; Stawell, SAMA; Swan Hill, NMV; Traralgon Ck, NMV; Violet Town, ANIC; East Warburton, NMV; Wyperfeld Nt Pk, ANIC.

Western Australia

15 km SSE Armadale, ANIC; 102 km SE by E, Broome, ANIC; 12 km NE Broome, ANIC; Bunbury, ANIC; 23 km NW by W Mt Arid, ANIC; 7 miles NE Giles, WAM; Gill Pinnacle, WAM; Great Victoria Desert, WAM; Mary sp. HS, ANIC; 13 km ESE Mooka H.S., WAM; Koolan Island, WAM; Serpentine River, NMV; West Peawah River, ANIC; Wilga, ANIC; Wingello, ANIC.

Remarks

Enochrus elongatus differs from all other Australian *Enochrus* by the pale coloured dorsal surface including the head. It is the only Australian species with the tip of the aedeagus distinctly hooked upwards and with a basal swelling on the meta- and mesoclaws as well as the proclaws.

The rear of the head is variably coloured. In many specimens it is darker than the front of the

head, but diffusely so and never black and sharply delineated from the front as in most other species.

Enochrus elongatus superficially resembles the pale morphs of *E. deserticola* and *E. eyrensis* in size and colour. It also shares with them, and no other Australian species, the hooked parameres. Unlike them the black colour morph common in these two species does not appear to occur in *E. elongatus*. In both *E. deserticola* and *E. eyrensis* the head is predominantly black with only small patches of yellow-brown on the front angles. In *E. elongatus* the head is uniformly yellow-brown or the rear is diffusely darker. In *E. deserticola* the dorsal punctation is much weaker than in *E. elongatus* and in *E. eyrensis* it is stronger.

Enochrus elongatus is a widespread and common species within Australia including Norfolk Island. I can find no significant difference between Australian specimens and the types of *E. caledonicus* thus extending the range of *E. elongatus* to New Caledonia.

Enochrus (Methydrus) esuriens (Walker)

Philhydrus esuriens Walker, 1858

Enochrus (Lumetus) esuriens (Walker): Knisch 1924

Enochrus (Methydrus) esuriens (Walker): d'Orchymont 1927

= *Philhydrus pullus* Fauvel, 1883: syn. nov.

= *Enochrus (Lumetus) pullus* (Fauvel): Knisch 1924

Types

Enochrus esuriens: Type locality: Ceylon (Sri Lanka). Type not seen.

Enochrus pullus: *Lectotype*: ♂ 'Coll. IRSNB, Nouvelle Caledonie, Anse Vata, Marais Juill Octobre Rec. Savés, ex. coll. Fauvel'; 'Coll. et det A. Fauvel *Philhydrus pullus* Fvl. IRSNB 17–497', IRSNB with red lectotype label, herein designated. Seen.

Paralectotypes: 3 ♂, 1 ♀, same data as lectotype in IRSNB.

I have not seen type material of *E. esuriens* and have relied on the work of Balfour-Browne (1939, 1945) and specimens identified by him in BM(NH) for my concept of this widespread species which is known from India, through South-East Asia to Northern Australia and Polynesia.

Description (number examined, 130) Figs 13, 18

Length 1.6 mm – 2.3 mm. Oblong-oval. Elytron and pronotum light-testaceous, often blotched and streaked darker, head black, area in front of eye, to about width of eye light-testaceous, central black panel two to three times width of lateral light area. Ventral surface dark-testaceous, appendages lighter towards extremities, whole of apical segment of maxillary palpi usually darker. Punctures on head moderately strong, systematic punctures inwards from eyes about size of eye facet and about twice diameter of adjacent punctures. Punctures on pronotum somewhat weaker, punctures on elytra somewhat stronger than on head, those towards apex and laterally about half diameter of adjacent serial punctures which are often not easy to trace. Mesosternal keel weakly developed.

Male: Aedeagus narrow, pointed, virtually lacking terminal dorsal pad, shorter than parameres, collar nearer base than tip, parameres broad in basal half narrow for most of apical half, inner edge only very weakly sinuate, tips rounded. Proclaw straightened, strongly swollen at base, meso- and metaclaws rounded, swollen at base.

Distribution

New South Wales

Wootton, ANIC.

Northern Territory

Adelaide River, ANIC; E Alligator River, AM; Darwin, ANIC; Humpty Doo, QDPIM; 12 km N Humpty Doo, QDPIM; 6 km N Humpty Doo, QDPIM; Jim Jim Creek, ANIC; 9 km N by E Mudginbarry HS, ANIC; 19 km E by S Mt Borradaile, ANIC; 12 km NNW Mt Cahill, ANIC; Nourlangie Creek, ANIC; Oenpelli, AM.

Queensland

Annan Falls, ANIC; Ayr, ANIC; 29 km S Bamaga, ANIC; Cairns, ANIC, SAMA; Calliope River, ANIC; Cardstone, ANIC; 60 km S Coen, SAMA; 40 km N Coen, SAMA; Ingham, ANIC; Lansdowne St, ANIC; 73 km NW Laura, ANIC; Laura, QDPIM; Macleod River, SAMA; Mackay, ANIC; Mareeba, QDPIM; Mary Creek, ANIC; Mt Baird, ANIC; Mt Coolum, ANIC; Mt Ivor River, ANIC; Mt Molloy, ANIC; 2 km NNE Mt Tozer, ANIC; 11 km ENE Mt Tozer, ANIC; 8 km E by N of Mt Tozer, ANIC; 12 km S Normanton, SAMA; North Pine River, UQIC; Port Douglas, ANIC; Redcliff, UQIC; 15 km WNW South Johnstone, QDPIM; Townsville, ANIC, SAMA; Weipa, QDPIM.

Western Australia
Mitchell Plateau, ANIC; Nullagine, WAM.

Remarks
Enochrus esuriens' small size (<2.5 mm), predominantly black head and weak mesosternal keel make it one of the most readily recognised species of Australian *Enochrus*. It is most easily confused, not with other *Enochrus*, but with species of *Paracymus* and *Anacaena*. These latter genera lack the systematic punctures present on the head, pronotum and elytra of *Enochrus*.

Enochrus (Methydrus) eubenangeei sp. nov.

Types
Holotype: ♂, 'Qld. Babinda Eubenargee Swamp, 1/4/96, C. Watts', SAMA.
Paratypes: 6, 'Bramston Beach via Innisfail, N.Q., 15 Aug. 1987, A. Walford-Huggins, coastal melaleuca swamp at light', ANIC; 1, 'N.T. Corndorl billabong nr. Jabiru, M.V. light, 2.x.1982, M.B. Malipatil', NTM.

Description (number examined, 8) Fig 10
Length 7.0– 7.5 mm. Broadly oval, relatively flat. Shiny. Black; palpi and tarsi testaceous. Maxillary palpi moderately long, pseudo first segment longer than distance from eye to front of clypeus, longer than maxillary stipe, apical segment approximately three-quarters length of penultimate. Head strongly punctate, most punctures about a puncture width apart, almost size of eye facet. Systematic punctures large, about 3x size of adjacent punctures. Punctures on pronotum well marked, similar to those on head, not greatly weaker laterally, systematic punctures well marked about 3x size of adjacent punctures, lateral margins grooved and flanged, front and rear margins weakly grooved. Elytral punctures as on pronotum, not greatly weaker laterally. Serial punctures in four loose rows, relatively well marked, more numerous but more scattered laterally, elytra weakly grooved and flanged laterally. Mesosternal pillar well marked, sharply triangular in front view, front edge sloping, ventral edge short slightly pointed at rear, rear edge vertical in top half. Notch on apical sternite shallow, relatively broad.

Male: Aedeagus with very broad basal portion and narrow apical portion which is curved upwards. Parameres relatively broad, hooked outwards at tips, bent upwards in apical half. Proclaws bent, broadly thicker in basal third, thickened part ends abruptly, meso- and metaclaws curved, basal third somewhat thickened, thickened part ending smoothly.

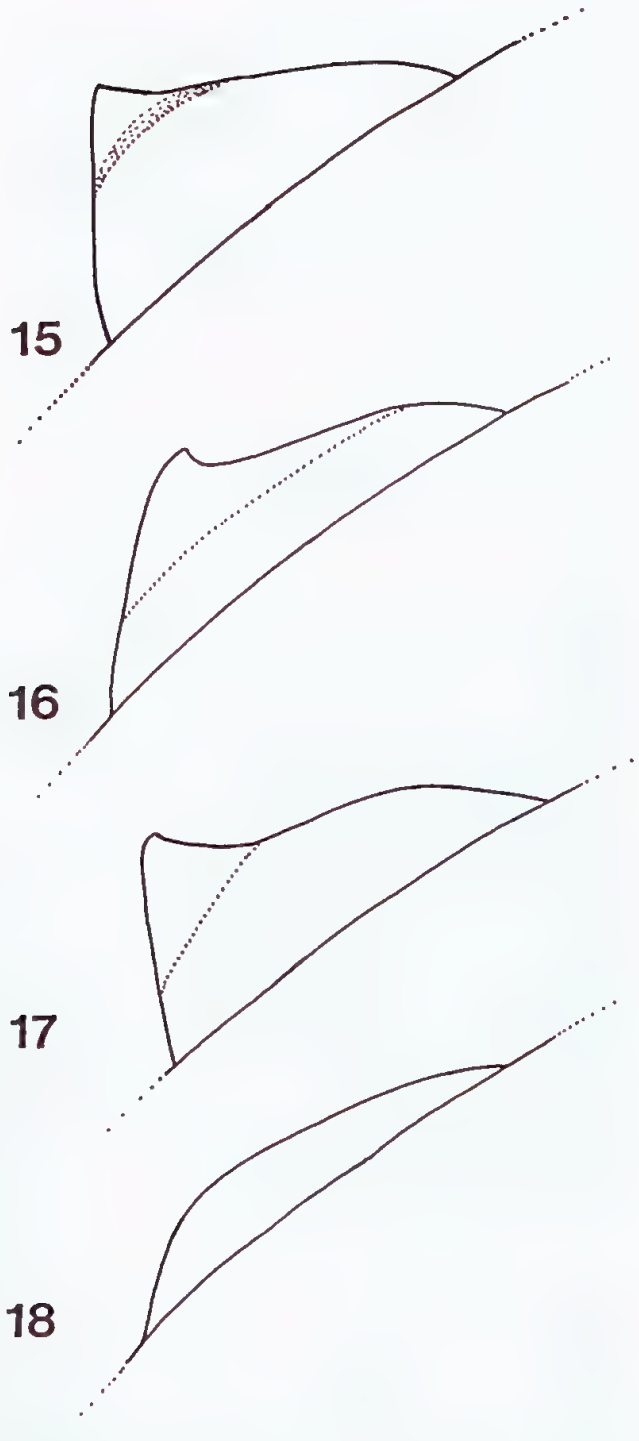
Remarks
Enochrus eubenangeei closely resembles *E. aliciae*. Apart from the genitalia it differs from *E. aliciae* in the lateral punctures on pronotum and elytra being almost as strong as more central ones and a greater extent of black. Based on the relatively few specimens of both species that are available *E. eubenangeei* also differs from *E. aliciae* by its black head, whereas in many *E. aliciae* the head has some testaceous colour, and by the broader but narrower exposure of the membrane between frons and clypeus than in *E. aliciae* where it is shorter but deeper.

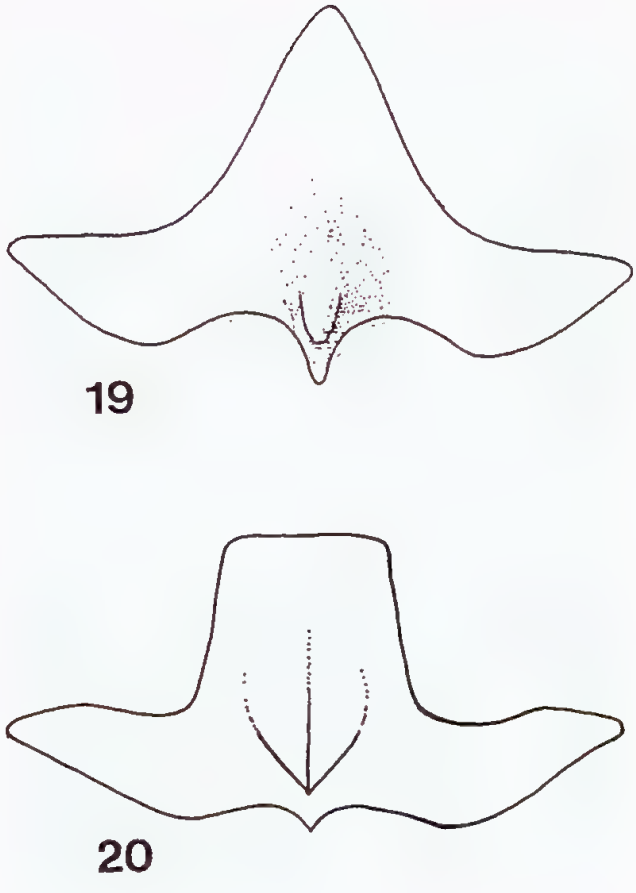
The aedeagi are distinct. *Enochrus eubenangeei* has a normal narrow apical portion to the aedeagus, without apical pad but bending strongly upwards. *Enochrus aliciae* has a very broad basal portion but, uniquely among Australian *Enochrus*, lacks the apical portion, resulting in the aedeagus reaching little beyond half way along the parameres. The parameres are rather similar but the tips are more obviously hooked in *E. eubenangeei* and they bend noticeably upward in this species.

In its relatively large size, rounded shape and shiny, black appearance, *E. eubenangeei* also resembles *E. mastersi*. It, and *E. aliciae*, can be most readily separated from this more common species by the longer maxillary palpi with the apical segment shorter than the penultimate. The only other species it could be confused with is *E. isabellae* which is smaller, narrower, has light areas in front of its eyes and has the mesosternal process long and blade-like.

Distribution
Known only from type localities in Northern Territory and Queensland.

Enochrus (Methydrus) eyrensis (Blackburn)
Philhydrus eyrensis Blackburn, 1894
Enochrus (Lumetus) eyrensis (Blackburn): Knisch 1924
= *Philhydrus andersoni* Blackburn, 1896: syn. nov.
= *Enochrus (Lumetus) andersoni* (Blackburn): Knisch 1924
?= Philhydrus persimilis Régimbart, 1908: syn. nov.
?= Enochrus (Lumetus) persimilis (Régimbart): Knisch 1924





FIGURES 15–20. Mesosterna. **15–18**, Lateral view of mesosternal keel. **15**, *E. samae*; **16**, *E. eyrensis*; **17**, *E. maculiceps*; **18**, *E. esuriens*. **19** & **20**, mesosternum. **19**, *E. mastersi* (after Hansen 1990); **20**, *E. aliciae*.

Types

Enochrus eyrensis: Holotype: ♀, 'Blackburn coll. 1910–236', 'Philhydrus eyrensis Black', remounted with '178T' on original Blackburn card, BM(NH),

Paratypes: 2 'Philhydrus eyrensis Blackb co-type', 'Philhydrus eyrensis Blackb, C. Australia, co-type 8242', SAMA.

Enochrus andersoni: Holotype: ?sex. 'Blackburn coll. 1910–236', 'Philhydrus andersoni, Blackb' remounted with '178T' on original Blackburn card, BM(NH).

Synonymy based on examination of types.

Enochrus persimilis: *Holotype:* ?Victoria Aust; '*Philhydrus persimilis* Reg.' MNHN. Synonymy based on descriptions and examination of types (of *E. persimilis* in 1964, type not currently available). It is possible that my *E. samae* will prove to be this species.

Description (number examined, 146) Figs 5, 16

Oblong-oval, length, 3.2 mm – 5.0 mm. Two colour morphs exist, one with elytra and pronotum testaceous often with sutural lines and strial punctures darker, occasionally with disc of pronotum darker, head dark-testaceous to black with lighter area forward from eyes to about the same width as eyes giving a darker central panel three to four times the width of one of the lighter patches, clypeus dark. Second colour morph has the elytra dark-testaceous or black, pronotum a

similar colour but quite widely but diffusely lighter laterally, head as for first colour morph. Underside of both morphs dark-testaceous, appendages lighter towards extremities, except for maxillary palpi which have apical portion of apical segment darker.

Head quite densely covered with relatively strong punctures about half size of eye facet, a few large punctures inwards from eyes, 2–3x diameter of surrounding punctures. Punctures on pronotum slightly stronger, systematic punctures as in *E. elongatus*, 2–3x diameter of adjacent punctures. Punctures on elytra rather stronger than on pronotum, towards apex approaching size of serial punctures, which, as a consequence, are hard to trace.

Mesosternal keel well developed, anterior edge weakly curved, nearly perpendicular, ventral edge straight or weakly convex, narrow vertical 'blade' above an extensive broader base. Notch on apical sternite moderately developed.

Male: Aedeagus narrow, pointed, virtually lacking terminal dorsal pad, collar nearer base than tip. Parameres outwardly hooked at tip. Proclaw a little longer, less curved than in female, otherwise little sexual difference in claws.

Distribution

Australian Capital Territory

Black Mt, ANIC; Jarvis Bay, ANIC.

New South Wales

Bonville, ANIC; 25 km N Bulahdelah, ANIC; Maroota South, ANIC; 8 km SE by S Moruya, ANIC; Norfolk Island, ANIC; Queanbeyan, ANIC; 17 mls S Woodburn, ANIC; Wootton, ANIC.

South Australia

Adelaide, SAMA; American River, SAMA; Beachport, AM, SAMA; Bool Lagoon, SAMA; Coonalpyn, SAMA; Fairview Park Cons Pk, SAMA; Hindmash Park, SAMA; Lucindale, SAMA; Naracoorte, UQIC; Taratap Stn, SAMA.

Tasmania

Scamanden River, NMV; Swansea, SAMA.

Victoria

East Pomborneit, ANIC; Lorne, SAMA; Maffra, UQIC; Otway Rngs, UQIC; Wyperfeld Nt Pk, ANIC.

Western Australia

Albany, ANIC; Applecross, ANIC; Broomehill, WAM; Dumbleyung, WAM; 5 km NE Esperance, ANIC; 63 mls E Esperance, ANIC; 9 mls NE by N Esperance, ANIC; 19 km E Esperance, ANIC; 5 km NW Esperance, ANIC; Fitzgerald River Nt Pk, ANIC; Karridale, ANIC; Maidavale, SAMA; Mt Margaret, ANIC; Mandurah, ANIC; 23 km NW by N Mt Arid, ANIC; Perth, ANIC; 8 mls E Pinjarra, ANIC; Stirling Rngs, SAMA; 12 km NE Wanneroo, WAM; 155 km SW Warburton, WAM; Wilga, ANIC.

Remarks

This relatively large species is common in both the south-east and south-west.

The relatively strong dorsal punctation separates it from all other Australian *Enochrus* except *E. samae* and the generally much smaller *E. malabarensis*. *Enochrus malabarensis* is also a more northern species and lacks black morphs. From *E. samae, E. eyrensis* differs in having the parameres hooked at the tips rather than rounded and in a higher, more blade-like mesosternal keel. This latter character is, I believe, a good one but is hard to see on many specimens and is difficult to use if comparative material is not available.

Enochrus eyrensis appears close to *E. tristus* (Broun) from New Zealand and some Pacific Islands in the hooked parameres and strong punctations. It differs from this species in having the apical portion of the aedeagus shorter than the basal and in rounded, not slightly straightened, male metaclaws. *Enochrus eyrensis* differs from *E. abditus* (Sharp) from New Zealand, in details of the aedeagus and mesosternal keel.

Enochrus (Methydrus) isabellae sp. nov.

Types

Holotype: ♂, right-hand specimen on card, 'Qld. Townsville, 10 km NW, 23/3/96, C. Watts', SAMA.

Paratypes: 7, same data as holotype, SAMA; 3, 'Ayr Qld., 10.ix.1990, W.B. Muir', in ANIC; 1, 'Ingham, N.Q., 27.i.68, J.C. Brooks', ANIC; 1, 'Blighs Lookout, Cardwell Rng, N.Q. at light, 30.ix.67, J. Brooks', ANIC; 1, 'Bramston Beach via Innisfail, N.Q., 15.viii.1987, A. Walford-Huggins. Coastal melaleuca swamp at light', in ANIC; 6, 'Qld. Nardello's Lagoon nr. Mareeba 29/3/96, C. Watts', SAMA.

Description (number examined, 14) Fig 6

Length 4.5 mm – 5.5 mm. Oval, shiny. Black apart from lateral areas of pronotum, region in

front of eyes and appendages which are reddish-yellow. Tips of maxillary palpi darker. Head quite densely punctate, with weak to moderately sized punctures, systematic punctures rather sparse, somewhat larger than an eye facet and 2–3x size of adjacent punctures. Pronotum and elytra similarly punctured except that systematic punctures a bit larger in comparison with others. Mesosternal keel well-developed, narrow, often with small protuberance on anterior end.

Male: Claws on protarsi more bent than in female with broad basal portion. Parameres hooked apically, aedeagus with apical portion shorter than basal, relatively broad, narrowing rapidly at tip, slight but noticeable dorsal thickening at tip.

Distribution

Known only from type localities in Queensland.

Remarks

A relatively large nearly totally black species. It strongly resembles the black morphs of *E. eyrensis* and *E. samae* but is much more weakly punctured, has a shorter apical portion of the aedeagus than in *E. eyrensis* and has hooked parameres which distinguish it from *E. samae*. Compared to the black morph of *E. deserticola* which occurs sympatrically with it, it is larger, more strongly punctured and has more extensive black on the front of the head than is normal in *E. deserticola*. The male genitalia are relatively similar to those of *E. deserticola* but *E. isabellae* has a broader and shorter apical portion to the aedeagus with a more developed apical dorsal/ventral thickening. From *E. elongatus* it can be separated on colour, generally weaker punctation, weaker apical hook on aedeagus which ends well short of tips of parameres and lack of modified meso- and meta-claws in the males.

The Townsville and Nardello's Lagoon specimens were collected from shallow water among thick drying reeds at the edge of extensive shallow swamps.

Enochrus (Methydrus) maculiceps (MacLeay)

Philhydrus maculiceps MacLeay, 1873

Enochrus (Lumetus) maculiceps (MacLeay): Knisch 1924

= *Philhydrus laevigatus* Blackburn, 1888: syn. nov.

= *Enochrus (Lumetus) laevigatus* (Blackburn): Knisch 1924

= *Philhydrus artensis* Fauvel, 1883: syn. nov.

= *Enochrus (Lumetus) artensis* (Fauvel): Knisch 1924

= *Enochrus (Lumetus) bryani* d'Orchymont, 1927: syn. nov.

Types

Enochrus laevigatus: Holotype: 'Philhydrus laevigatus Blackb', BM(NH), 'Blackburn coll. 1910–236'. Remounted with '1552T' on original Blackburn label. Synonymy based on examination of types.

Enochrus maculiceps: Lectotype: Male. 'Philhydrus maculiceps McL W. Gayndah', 'K19505'. Right-hand specimen of two mounted on same card, AM, herein designated.

Paralectotypes: 1, on same card as lectotype, AM; 2, same data as lectotype and mounted on one card, in ANIC; "Philhydrus maculiceps McL. 'Co-type' Griffith collection id by A.M. Lea" ; 1, 'Philhydrus maculiceps McL. Queensland co-type 14631', SAMA. Synonymy based on examination of types.

Enochrus artensis: *Holotype*: 'Nouvelle Caledonie Ile Art', 'Rec. ex. coll. Fauvel', 'Coll. et det. A. Fauvel *Philhydrus artensis* Fvl', with red Holotype label, IRSNB.

Paratype: ♀, 'Nouvelle Caledonie Kanata Re Deplenche ex. coll. Fauvel'; 'Coll. et det. A. Fauvel *Philhydrus artensis* Fvl, IRSNB 17–479', with orange paratype label, IRSNB. Synonymy based on examination of types.

Enochrus bryani: *Holotype:* 'Savaii Samoa', 'Salailua v–22–24', 'H. Bryan Jr, Collector', ♂, 'Type', 'A. d'Orchymont det, *Enochrus (Lumetus) bryani*',Bishop Museum, Honolulu.

Paratype: '*Enochrus* (*Lumetus) bryani* A. d'Orchymont det'; 'Samoan Is. Apia Upolu Is'; 'female' 'I Samoa Mars 1924 Coll. d'Orchymont', IRSNB.

Both the types are mounted on card from the same source and similarly labelled by d'Orchymont. d'Orchymont clearly identified the Bishop Museum specimen as the holotype. Unfortunately all but a hind tibia and tarsus of the holotype has been lost. I base my concept of *E. bryani* on the Brussels paratype and d'Orchymont's description and illustration of the aedeagus.

Description (number examined, 134) Figs 1, 2, 17

Length 2.6 mm – 4.0 mm. Elytra testaceous, sutural lines, some serial punctures and a rough, small patch on each humeral angle darker; pronotum testaceous, disk rather darker than sides; head with testaceous areas in front of each

eye much wider than eye, central dark panel about half width of lateral light patches, boundary between areas often diffuse. Ventral surface dark-testaceous, appendages only slightly lighter towards extremities, maxillary palpi with tip of apical segment darker. Punctures on head moderately sized, a few larger punctures inwards from eyes a little smaller than eye facets and about 4x diameter of adjacent punctures. Pronotum similarly punctate, systematic punctures relatively weak, smaller than eye facets. Interstrial punctures on elytra weak, verging on subobsolete, serial punctures also relatively small and weak, both a little stronger apically and laterally, on humeral angle the serial punctures are about 3x the diameter of adjacent punctures but both are small and relatively weak. Mesosternal keel moderately developed, ventral edge flat except for a well developed anterior protuberance.

Male: Genitalia variable in elongation, aedeagus usually relatively broad, narrowing to rounded point, collar closer to base than tip. Parameres relatively narrow, pointed. Male and female claws similar.

Distribution

Australian Capital Territory

Blundello Creek, ANIC; Canberra, SAMA.

New South Wales

Albury, ANIC; Ashfield, AM; Balranald, NMV; Berry, SAMA; Bogan River, AM; 20 mls SSW Bourke, SAMA; Collector, SAMA; Congo, ANIC; 9 km NNE Coonabarabran, ANIC; 14 km W Coonabarabran, ANIC; De Burghs Rng, AM; Deniliquin, ANIC; 37 km E Hay, SAMA; Illadulla, ANIC; Jenolan Caves, SAMA; Kenilworth, ANIC; North Sydney, NMV; Tooloom Plateau, UQIC; Wallacia, SAMA; Wilcannia, SAMA; 3 km S Wingellow, ANIC; Wingham Scrub, ANIC; Wootton, ANIC; Valery, ANIC.

Northern Territory

30 mls W Alice Springs, ANIC; Stanley Chasm, SAMA; 100 mls W Mt Olga, WAM; 30 km N Wauchope, ANIC; Yuendumu, SAMA.

Queensland

31 km NE Aramac, SAMA; Atherton, QDPIM; Babinda, UQIC; Brisbane, UQIC, SAMA; Bundaberg, ANIC; Byfield, ANIC; Cardstone, ANIC; Clermont, AM; Edungalba, ANIC; Funnel Creek, ANIC; 50 mls W Mackay, ANIC; Mt Coolum, ANIC; 9 mls S Stanthorpe, ANIC;

South Australia

Arkaba Creek, SAMA; 80 mls S Cooper Pedy, SAMA; 10 km SE Coward Springs, SAMA; Murray River, SAMA; Wintana Station, SAMA.

Victoria

Healsville, SAMA; Maffra, UQIC; Nathatia, SAMA; Portland, SAMA; 13 km SE Shepperton, ANIC; 14 km NW Violet Town, ANIC.

Western Australia

Nr Mt Gibson, WAM; 3 km E by N Newman, ANIC.

Remarks

A widespread and common species resembling a small *E. deserticola* and difficult to separate from light morphs of this species without reference to the male genitalia. Somewhat more strongly punctured than in most *E. deserticola*. In the North-east, *E. maculiceps* is sympatric with *E. weiri* and *E. pseudoweiri* which it closely resembles in general form. Both these species are a little more strongly punctured and have pale tips to their maxillary palpi and usually only a small central triangular area of black on the front of the head. However *E. maculiceps* with pale palpi and the central black portion on the front of the head reduced to a triangle, are not uncommon.

The male genitalia are variable in elongation, from a squatter form with the aedeagus quite curved in lateral view, with a strong apical pad and with only a small amount of structure apical to the pad, through to a more elongate form with elongate parameres, nearly straight aedeagus with a weak apical pad and a quite pronounced broadly triangular portion apical to the pad.

Some more strongly punctured specimens of *E. maculiceps* may approach weaker punctured specimens of *E. malabarensis*. In *E. malabarensis* the front of the head is nearly all black whereas in *E. maculiceps* the black area is seldom more than a third the width of the front of the head.

I have compared Australian specimens with the holotype, a paratype and five other specimens of *E. artensis* Fauvel from New Caledonia in IRSNB including two dissected males and consider that *E. artensis* is a junior synonym of *E. maculatus*.

Enochrus (Methydrus) malabarensis (Régimbart)

Philhydrus malabarensis Régimbart, 1903

Enochrus (Lumetus) malabarensis (Régimbart): Knisch, 1924

Types

Enochrus malabarensis: *Holotype*. 'Make, Calicut Ind'; '*Philhydrus malabarensis* Reg', MNHN.

Description (number examined, 37) Fig. 12

Length 2.5 mm – 4.1 mm. Broadly oval. Elytron and pronotum coloured as for *E. pseudoweiri*. Head black, areas in front of eyes light testaceous to about width of eye, central black panel 3–4x width of lateral light area. Ventral surface as for *E. pseudoweiri*, tips of maxillary palpi sometimes a little darker than rest of palpi. Punctures on head relatively strong, often approaching the size of eye facet, systematic punctures inwards from eye a little larger, sometimes hard to trace. Pronotum moderately to strongly punctured, systematic punctures often hard to trace. Punctures on elytra somewhat stronger towards apex and sides, approaching size of serial punctures which, as a consequence, may be difficult to distinguish. Mesosternal keel moderately developed, pronounced protuberance anteriorly, composed almost entirely of broad basal portion.

Male: Aedeagus relatively short, narrow, pointed with only slight apical pad, collar equidistant from tip and base. Parameres broad in basal half, narrow in apical quarter, inner edges almost straight, tips rounded. Proclaw rounded or weakly straightened strongly swollen at base, meso- and metaclaws, rounded.

Distribution

New South Wales

Ashfield, AM; Bondi Heights, AM; Sydney, NMV, SAMA.

Northern Territory

Black Point Coburg Peninsula, ANIC; Coastal Plains Research Stn, ANIC; Crocodile Island, SAMA; Darwin, ANIC, SAMA; Groote Eyland, SAMA; Howard Springs, ANIC; Kakadu NP, ANIC.

Queensland

Bowen, SAMA; Brisbane, UQIC; Bundaberg, ANIC; Stewart River, SAMA.

South Australia

Billa Kalina Station, SAMA.

Remarks

The moderate size and strong dorsal punctation separate *E. malabarensis* from all other Australian *Enochrus*. The punctation is strongest in specimens from the Darwin area where the systematic punctures on pronotum and elytra are virtually untraceable. The punctures get weaker to the south were some specimens can approach the situation in the most strongly punctate *E. maculiceps*, *E. pseudoweiri* and *E. weiri*. The greater extent of black on the front of the head (the pale area reduced to the width of an eye) will separate *E. malabarensis* from these species where the black portion covers <1/3 of the head width. *Enochrus malabarensis* has the unusual combination of strongly black head with pale tips to the maxillary palpi.

The male genitalia of *E. malabarensis* differ from those of *E. maculiceps* in that the inner margin of the parameres are straight rather than sinuate to accommodate the apical pad on the aedeagus. Although the tip of the aedeagus in *E. malabarensis* is thickened dorsoventrally, it is not laterally expanded (to varying degrees) as in *E. maculiceps*.

The mesosternal keel is stronger than in *E. weiri* and *E. pseudoweiri* and most specimens of these species lack the pronounced anterior downward protuberance found in both *E. malabarensis* and *E. maculiceps* (Fig. 17). The genitalia of *E. weiri* is distinctive, that of *E. pseudoweiri* quite closely resembles *E. malabarensis* but has a shorter and thinner aedeagus.

Enochrus malabarensis differs from the two other strongly punctate Australian *Enochrus* (*E. eyrensis* and *E. samae*) by its smaller size, lack of black colour morphs, usually pale maxillary palpi, stronger punctation particularly on the head and the strong downward protuberance at the front of the mesosternal keel which is usually lacking in *E. eyrensis* and *E. samae*. *Enochrus malabarensis* has a generally more northern distribution than the other two species but overlaps with *E. eyrensis* on the east coast. The male genitalia readily separate the species (Figs 5, 12).

I have not seen the type of *E. malabarensis* (it is unavailable at this time) and have based my concept of this species on specimens identified by d'Orchymont from Sulawesi in IRSNB.

***Enochrus (Methydrus) pseudoweiri* sp. nov.**

Types

Holotype: ♂, '16°03'S to 16°05'S, 145°28'E, Cape Tribulation area, Qld., 21–28 Mar 1984, A. Calder and T. Weir'. ANIC.

Paratypes: All male. 4, "Cardwell Rng, N.Q., 30.9.87, G.B. 'Q363'; 'J. G. Brooks Bequest 1976', ANIC; 2, '15°03'S, 145°09'E, 3 km NE of Mt Webb, Qld., 1–3 Oct. 1980, T. Weir', ANIC; 1, 'Whitfield Rg., Rd., ca. 486 m, Qld., 3.ii.1970, at light, J. G. and J. A. G. Brooks', ANIC; 1, '12°44S, 143°17'E, 8 km E by N of Mt Tozer, Qld., 7 July 1986, T. Weir and A. Calder', ANIC; 2, McIvor Rv., 25 mls N Cooktown, N Qld, 6 May 1970, S. R. Curtis', one ANIC, one SAMA; 1, 'Australia, N Qld, Iron Range, 26–31.x.1991, Wood, Dunn and Hasenpusch', QDPIM; 1, 'Cow Bay, N of Daintree N Qld, 20–1 7–11 1984 1, C. Cunningham', QDPIM; 1, 'Cow Bay, N of Daintree, Qld., 27/7/82, C. Watts', SAMA; 4, 'Peach Ck, N Qld., 24/7/87, C. Watts', SAMA; 1, 'Cairns, C. J. Wild, Jan 91', QM.

Description (number examined, 33) Fig. 3

Length 3.0 mm – 3.6 mm. Oblong oval. Elytra testaceous to dark-testaceous, sutural region and serial punctures darker; small darker patch on humeral angles in many specimens. Pronotum dark testaceous centrally, widely lighter laterally. Head dark testaceous-black, frons area light testaceous except for small triangularly shaped dark area with apex often not reaching front of head, boundary between darker area and light areas indistinct, clypeus dark testaceous, ventral surface dark testaceous, appendages somewhat lighter towards extremities, maxillary palpi lacking darker tip. Head sparsely covered by small weak punctures, much smaller than facets of eyes, a few larger punctures inward from eyes about size of eye facet and 2–3x larger than adjacent punctures. Elytral punctures a little stronger, shallow. Serial punctures relatively weak, hard to trace laterally except on humeral angles where they are more distinct and 3–5x the diameter of adjacent punctures. Mesosternal keel strongly raised, ventral edge weakly convex, usually with a distinct anterior protuberance, broader basal portion making up most of keel with only a narrow thinner section in lateral view.

Male: Genitalia very stout to moderately stout overall. Aedeagus very slender, lacking terminal pad, collar nearer base than tip. Parameres broad, tips rounded. Proclaws curved, strongly swollen in basal half, more so than in female.

Distribution

Queensland

Cairns, ANIC; Cardstone, ANIC; Cardwell, ANIC; Cape Tribulation area, ANIC; 3km S by W of Cooktown, ANIC; 25mls N Cooktown, ANIC, SAMA; Cooktown, ANIC; 2mls N Kuranda, ANIC; 8km E by N of Mount Tozer, ANIC; 3km NE of Mount Webb, ANIC; Peack Ck, SAMA; 15km WSW South Johnstone, QDPIM; Whitfield Rg Rd, ANIC.

Northern Territory

Howard Springs, ANIC.

Remarks

Apart from the male genitalia and a tendency for the darker portion at the front of the head to be larger and more diffuse, I can find no difference between this species and *E. weiri* (see under *E. weiri*).

Enochrus (Methydrus) samae sp. nov.

Types

Holotype: ♂, 'East Pomborneit, Vic. 24 km ESE Camperdown. Temporary pond, Aug. 1978–Feb. 1979, P.S. Lake coll.', ANIC.

Paratypes: 2 ♂, same data as holotype, ANIC; 2 ♀, '29.01°S, 167.57°E, Norfolk Island, Filmy Fern Walk, 14 Nov. – 2 Dec. 1984, I.D. Naumann ex ethanol', ANIC; 4 ♀, 4 ♂, 'Stonor, Tas: Lea', SAMA; 'Swansea, Tas., Jan. C. Watts', SAMA; 1 ♀, 1 ♂, '10 km S Robe S.A., 1/83, C. Watts', SAMA; 2 ♂, 'Grampians, Vic., 2.63, C. Watts', SAMA; 1 ♂, 'Chain of Ponds, S.A., December 1957, C. Watts', SAMA; 1 ♂, 'Mylor, S.A., Aug. 1958, C. Watts', SAMA.

Description (number examined, 47) Figs 9, 15

Length 4.0 mm – 5.0 mm. Oblong-oval. Elytra and pronotum dark-testaceous, quite broadly lighter at sides, dark area broken up with longitudinal rows of spots towards apex, front of pronotum often narrowly light-testaceous. Head dark-testaceous to black except for broad light-testaceous areas forward from eyes, leaving a central dark panel which is about the same width as one of the pale patches, boundary between the dark central panel and pale patches diffuse. Underside dark-testaceous, appendages only slighter lighter towards extremities, apical portion of apical segment of maxillary palpi darker. Punctures on head relatively strong, not much smaller than eye facet, a few larger punctures inward from eyes, about 3x the diameter of adjacent punctures; pronotal punctures on elytra a

little stronger than on pronotum, towards apex and laterally approaching size of strial punctures which are consequently not easily traced. Mesosternal keel moderately developed, triangular shaped, broader basal portion makes up most of keel.

Male: Aedeagus broad, well-marked terminal dorsal pad, collar nearer to base than to tip. Parameres with rounded tips. Male proclaws greatly swollen in basal half, strongly curved in apical half, female less swollen and more evenly curved.

Distribution

Australian Capital Territory
Black Mt., ANIC.

New South Wales
Norfolk Isl., ANIC.

South Australia
Chain of Ponds, SAMA; Mylor, SAMA; 10 km S Robe, SAMA.

Tasmania
George Town, SAMA; Stonor, SAMA; Swansea, SAMA.

Victoria
Grampians, SAMA; Hamilton, NMV; Lorne, SAMA; Otway Rngs., UQIC; East Pomborneit, ANIC.

Remarks

In general facies this species is very similar to *E. eyrensis* and at least in the South-east occurs sympatrically with it. The strong dorsal punctation and patterned head readily separates these two species from other *Enochrus* in the region. *Enochrus samae* differs from *E. eyrensis* in having rounded rather than hooked tips to the parameres and in a squatter mesosternal keel. This latter character is hard to use if comparative material is not available

***Enochrus (Methydrus) weiri* sp. nov.**

Types

Holotype: ♂, '12°44'S, 143°14'E, 3 km ENE of Mt Tozer, Qld., 28 Jun – 4 Jul 1986, T. Weir and A. Calder', ANIC.

Paratypes: All ♂. 1, '12°44'S, 143°17'E, 8 km E by N of Mt Tozer, Qld., 7 July 1986, T. Weir and A. Calder', ANIC; 1, '12°44'S, 143°14'E, 3 km ENE of Mt Tozer, Qld., 28 Jun – 4 Jul 1986, T. Weir and A. Calder', ANIC; 2, '12°43'S, 143°17'E, 9 km ENE of Mt Tozer, Qld., 5–10 July 1986, T. Weir and A. Calder', one ANIC, one SAMA; 1, 'Dejinghe Ck, N.Q., 3 mls SW of Yarrabah, 26.x.1966 E. Britton, R Trumble', ANIC; 1, '16°03'S to 16°05'S, 145°28'E Cape Tribulation area, Qld., 21–28 Mar 1984, A. Calder and T. Weir', ANIC; 1, 'Australia, N Qld., Cow Bay N of Daintree R, 13.ix.1990, Cunningham and DeFaveri', QDPIM; 1, 'Australia, N Qld Cow Bay N of Daintree R, 14.xii.1987–6.i.1988, Storey and Cunningham', QDPIM.

Description (number examined, 18 with male genitalia extracted) Fig. 8

As for *E. pseudoweiri* except for male genitalia.

Male: Aedeagus broadest in middle, tapering to a point, lacking any terminal dorsal pad. Tips of parameres truncated, weakly bifid.

Distribution

Known only from type localities on Cape York in North Queensland.

Remarks

A tropical species known only from the Queensland east coast, north of Cairns. I have found no reliable way to separate this species and *E. pseudoweiri*, with which it is sympatric over most of its range, other than by the distinctively different male genitalia. These species can also be readily confused with *E. maculiceps* and with small brown colour morphs of *E. deserticola* which also occur in the region. The virtual absence of black on the front of the head and pale tips to the maxillary palpi will separate them from most examples of these species. Most *E. weiri* lack or have only a small downward protuberance at the front of the mesosternal keel whereas most *E. maculiceps* have it well developed. The differently coloured head and weaker dorsal punctures will readily separate *E. weiri* from the similarly sized *E. malabarensis*.

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References

ANDERSON, J. M. E. 1976. Aquatic Hydrophilidae (Coleoptera). The biology of some Australian species with descriptions of immature stages reared in the laboratory. *Journal of the Australian Entomological Society* **15**: 219–228.

BLACKBURN, T. 1888. Notes on Australian Coleoptera with descriptions of new species. *Proceedings of the Linnean Society of New South Wales* **3**: 805–875.

BLACKBURN, T. 1894. Further notes on Australian Coleoptera, with descriptions of new genera and new species. *Transactions of the Royal Society of South Australia* **18**: 139–168.

BLACKBURN, T. 1896. Coleoptera (exclusive of the Carabidae). Pp. 254–308 *in* B. Spencer (ed.) 'Report on the work of the Horn Expedition to Central Australia', Part 2 – Zoology. Melville, Mullen and Slade: Melbourne.

FAUVEL, A. 1883. Les Coléoptères de la Nouvelle-Calédonie et dépendances avec descriptions, notes et synonymies nouvelles. *Revue d'Entomologie, Société Française d'Entomologie* **2**: 335–360.

GENTILI, E. 1981. The genera *Laccobius* and *Nothydrus* (Coleoptera: Hydrophilidae) in Australia and New Zealand. *Records of the South Australian Museum* **18**(7): 143–154.

HANSEN, M. 1990. *Hydatotrephis* MacLeay, a subgenus of *Enochrus* Thomson (Coleoptera: Hydrophilidae). *Entomologica Scandinavica* **21**(1): 71–76.

HANSEN, M. 1991. The Hydrophiloid Beetles. Phylogeny, Classification and a Revision of the Genera (Coleoptera: Hydrophilidae). Pp. 348. *Biologiske Skriften* **40**. The Royal Danish Academy of Science and letters, Kommissionaer: Munksgaard, Copenhagen.

KNISCH, A. 1922. Results of Dr E. Mjöberg's Swedish Scientific Expeditions to Australia 1910–1913. 29. Hydrophilidae. *Arkiv för Zoologi* **14**: 1–4.

KNISCH, A. 1922. Hydrophiliden–Studien (op.10). *Archive für Naturgeschichte* **88**: 87–126.

KNISCH, A. 1924. Hydrophilidae. Pp 306 *in* W. Junk & S. Schenkling (eds) 'Coleopterum Catalogus XIV, pars 79'. Berlin.

MACLEAY, W. 1873. Notes on a collection of Insects from Gayndah. *Transactions of the Entomological Society of New South Wales* **2**(1873): 79–205.

d'ORCHYMONT, A. 1927. Papers on Malayan Aquatic Biology. *Journal of the Federated Malay States, M.S. Museum* **13**: 248.

RÉGIMBART, M. 1903. Voyage de M. Maurice Maindron dans L'Inde Méridionale. Dytiscidae, Gyrinides et Palpicornes. *Annales de la Société Entomologique de France* **72**: 331–339.

RÉGIMBART, M. 1908. Dytiscidae, Hydrophilidae et Gyrinidae. Pp. 311–316 *in* W. Michaelsen & R. Hartmeyer (eds) 'Fauna Südwest-Australiens,1.VIII. Jena.

WALKER, F. 1858. Characters of some apparently undescribed Ceylon insects. *Annals and Magazine of Natural History* **2**(series 3): 202–209.

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CONTENTS PAGES

BARKER, S. 21–23
Selection of lectotypes and redescriptions of three *Cisseis* (Coleoptera: Buprestidae) species.

CHILD, C. A. 1–19
Pycnogonida from Prydz Bay, East Antarctica.

CLARKE, P. A. 149–163
Spirit beings and the Aboriginal landscape of the Lower Murray, South Australia.

FITZPATRICK, P. 181–214
The A. P. H. Freund Collection of New Guinea Artefacts held by the South Australian Museum.

HERCUS, L. A. & POTEZNY, V. 165–180
'Finch' Versus 'Finch-Water': A Study of Aboriginal Place-Names in South Australia.

MEDLIN, G. C. 119–125
Obituary – Meredith Joan Smith

MURRAY, P. F. & MEGIRIAN, D. 51–97
The skull of dromornithid birds: anatomical evidence for their relationship to Anseriformes.

O'DONOGHUE, M. 127–147
The Egyptian Column at the South Australian Museum.

OPRESKO, D. M. 99–111
Three new species of *Leiopathes* (Cnidaria: Anthozoa: Antipatharia) from southern Australia.

PIKE, G. R. & CRAIG, B. 215–253
The Usher Photographic Collection from the South-West Pacific.

TILBROOK, K. J. 25–49
The species of *Antropora* Norman, 1903 (Bryozoa: Cheilostomatida), with the description of a new genus in the Calloporoidea.

ZBIK, M. & PRING, A. 113–115
The Poolowanna: A (H5) chondrite from the Simpson Desert of South Australia.

ZEIDLER, W. & GOWLETT-HOLMES, K. L. 117–118
Confirmation of the association of the hyperiidean amphipod genus *Hyperia* (Crustacea: Amphipoda: Hyperiidea: Hyperiidae) with ctenophores.

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MUSEUM VICTORIA

PYCNOGONIDA FROM PRYDZ BAY, EAST ANTARCTICA

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A small but rich collection of pycnogonids was gathered by personnel of the R/V 'Aurora Australis' of the South Australian Museum, in Prydz Bay (stations from 68°50'E to 78°11'E), eastern Antarctica. The Collection is listed by station number with 300+ specimens consisting of 25 species (2 additional species remain identified only to genus) in 12 genera and 6 families. There is one new species, *Colossendeis adelpha*, which is described, illustrated, and compared with its congeners. An aberrant hirsute specimen of *Decolopoda australis* Eights is illustrated and compared with typical specimens of that species.

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These collections were made on the R/V 'Aurora Australis' during February and March, 1991, while in Prydz Bay, eastern Antarctica (68°50'E to 78°11'E). This pycnogonid collection is diverse and includes specimens of 6 of the 9 described families with twelve genera and twenty five species (2 remain unnamed for lack of adult or undamaged material). It contains about 300+ specimens. A single new species, *Colossendeis adelpha*, is described, illustrated, and compared with a very similar congener. An aberrant hirsute specimen of *Decolopoda australis* Eights, the first example of this in the genus, is described, illustrated, and compared with more typical specimens of that common species.

Materials

This material is deposited in the South Australian Museum (SAM), Adelaide, and has been given SAM registration numbers. Several surplus specimens have been retained at the National Museum of Natural History (NMNH), Smithsonian Institution, and exchanged for Antarctic specimens not represented in the SAM collections.

The literature cited under each species is abbreviated because the recently published Antarctic survey reports by Child (1994a, b, 1995a, b, c) contain most pertinent literature and bibliography. Its duplication under the pertinent species in this report was not thought necessary.

Systematics

Class PYCNOGONIDA

Family AMMOTHEIDAE

This family contains the most heterogeneous group of genera found amongst the pycnogonids. All species have palps of from 4 to 10 segments, most have cheliphores and chelae in various stages of reduction or atrophy to complete loss, and all have ovigers carried by both sexes, although those of females are of reduced size.

Genus *Achelia* Hodge, 1864

Ammothea Leach, 1814 [part]

Ammothea (*Achelia*) Giltay, 1934.

Aduncorostris Fry & Hedgpeth, 1969

Diagnosis

Trunk discoid in dorsal outline, partially to fully unsegmented. Proboscis usually pyriform. Ocular tubercle usually low, with eyes. Abdomen short, erect. Cheliphores with short scape, chelae atrophied, reduced to knobs. Palps 7- to 9-segmented. Legs spinose, femur often inflated, cement gland with single tiny dorsodistal tube. Tarsus short, propodus very curved, with larger heel spines, smaller sole spines, robust main claw, and usually long auxiliary claws.

Achelia spicata (Hodgson, 1915)

Austrothea spicata Hodgson, 1915: 147.

Achelia spicata.– Calman, 1915: 57–60, figs. 13–14.– Child, 1994a: 10–11 [recent literature].

Achelia (Ignavogriphus) spicata.– Fry & Hedgpeth, 1969:109–110 [early literature], figs. 152–154, 157, 168–170, tables 13–14.

Material Examined

Sta. 25B (SAM E2930, 1♂).

Distribution

A common circumpolar species found from the intertidal to 1138 m.

Remarks

Species of this genus are known to be variable and this species is one with extreme variation. It even has two different morph groups in which the lateral processes are either crowded together or well separated. There are only two unvarying major characters in this species and both concern tubercles. The dorsolateral corners of the cephalic segment are smooth and do not have any form of tubercle, while tubercles are present more often than absent on these corners. The legs are also without tubercles except for the first coxae. These have only two dorsolateral setose tubercles instead of a more usual four found in many other species.

Genus *Ammothea* Leach, 1814

Lecythorhynchus Böhm, 1879

Leionymphon Möbius, 1902

Magnammothea Fry & Hedgpeth, 1969

Thavmastopycnon Fry & Hedgpeth, 1969

Athernopycnon Fry & Hedgpeth, 1969

Ecleipsothremma Fry & Hedgpeth, 1969

Anammothea Fry & Hedgpeth, 1969

Diagnosis

Habitus much larger than *Achelia*, trunk more slender, lateral processes well separated. Posterior rims of trunk segmentations expanded, often with tall conical dorsomedian tubercles. Ocular tubercle usually small, eyes well pigmented. Abdomen usually long. Cheliphores from fully chelate with reduced chelae, or atrophied chelae reduced to knobs, or scapes only without chelae, to no cheliphores whatsoever. Palps from 6- to 9-segmented, well developed. Ovigers 10-segmented in both sexes. Legs usually moderately long, cement gland small, with single dorsodistal pore.

Some species have small differences between the 4 anterior and 4 posterior propodi. These are: differences in heel spine number, overall length of the propodus, and length of the main and auxiliary claws.

Ammothea adunca Child, 1994a

Ammothea adunca Child, 1994a: 13–15, fig. 2.

Material examined

Sta. 52 (SAM E2931, 1♂).

Distribution

This species is known from a few localities in the vicinity of Heard Island on the Kerguelen Plateau, southern Indian Ocean, in depths of 175–800 m. The origin of this specimen, Prydz Bay, is due south of the type locality in the high Antarctic and extends its known distribution to that area.

Remarks

This recently described species is one of the few in this genus of mostly Antarctic species which has fully chelate cheliphores rather than having the chelae atrophy to become knobs in adults. Along with fully functional chelae, it also has very small palps which are shorter than the proboscis, while most species have palps longer than the proboscis.

There are four species of Antarctic and Subantarctic *Ammothea* which retain their chelae fingers in some form, whether functional or not, as adults. These are *A. longispina* Gordon, 1932, *A. gigantea* Gordon, 1932, *A. striata* (Möbius, 1902), and the present species. Of these four chelate species, only *A. longispina* and *A. adunca* have palps of reduced size and shorter than their narrowed proboscis. The palps sometimes have a reduced segment number (7, 8, or the usual 9 in *longispina*) from most other species which have nine. The present species also has palps with a reduced segment number (6 or 7), suggesting that the palps, at least in these two species, are in a transitional phase progressing toward reduced segment numbers. No specimens with the usual 9 segments of others have been found in this species.

The proboscis of both species is peculiar among ammotheids. In *A. longispina*, it is long, very

slender, and tapering to a narrow distal tube. The taper is even longer and narrower in juveniles. In *A. adunca*, it is swollen in its basal third and downcurved with its distal two thirds having a smaller diameter and a banana shape. The genus *Ammothea* is unique among the genera of pycnogonids in having such a diversity or reduction of cheliphore and palp segments. Its species range from having no cheliphores in any form to those with fully chelate cheliphores in conjunction with palps of 6 to 9 segments. The latter character of reduced palp segment number is not unique to *Ammothea*, but is shared by many species of the ammotheid genus *Tanystylum*.

Ammothea allopodes Fry & Hedgpeth, 1969

Ammothea spinosa var. Gordon, 1944: 50–51, figs. 16a–16e, 17.

Ammothea (*Mathoma*) *allopodes* Fry & Hedgpeth, 1969: 85–87, figs. 104, 105, 126–129.

Ammothea allopodes.– Clark, 1977: 174–175 [key].–Child, 1994a: 12–13 [key], 15.

Material examined

Sta. 52 (SAM E2932, 1♂, 2♀).

Distribution

This species has been taken at only a few localities which appear to encircle the Antarctic continent. It is known from depths of 210–540 m. It cannot be considered common.

Remarks

The bulbous chelae with atrophied fingers dorsal to the short egg-shaped proboscis help identify this relatively small species. Its dorsomedian trunk tubercles are almost square distally in lateral view and its moderately tall ocular tubercle is about equal to the height of these tubercles. This is one of the few *Ammothea* species which have shorter, more robust anterior propodi with an additional heel spine. The posterior four propodi are more slender, longer, and have only two heel spines in *A. allopodes*.

Ammothea glacialis (Hodgson, 1907)

Leionymphon glaciale Hodgson, 1907: 50–52, pl. VII, fig. 3.

Ammothea (*Ammothea*) *glacialis*.– Fry & Hedgpeth, 1969: 75–77 [literature], figs. 104, 105, 109–111.

Ammothea glacialis.– Clark, 1977: 174–175 [key].– Child, 1994a: 12–13 [key], 23–24.

Material examined

Sta. 52 (SAM E2933, 1♂); sta. 53 (SAM E2934, 1♂ with eggs, 1♀); sta. 54 (SAM E2935, 1♀).

Distribution

Distribution of this species is disjunct and is probably an artefact of uneven collecting efforts. It has been captured in the vicinity of South Georgia Island and along the eastern quadrants of the Antarctic continent in 0–500 m. It would be expected to occur in the vicinity of the Antarctic Peninsula and Palmer Archipelago, but the intensive American collecting efforts in these areas have not brought to light any additional specimens. Fry and Hedgpeth (1969:76, fig. 111) record this species as collected on the Antarctic Peninsula at one station (66°S, 67°W), but I have not found this specimen in the National Museum collections. There are not enough records for this species to provide significant distributional information.

Remarks

This rather large species has a massive, long, and inflated proboscis with very short cheliphores. Its dorsomedian tubercles are slightly taller than the low ocular tubercle but the dorsodistal tubercles on the lateral processes are very low or are lacking. All eight propodi are similar and do not vary in anterior and posterior pairs.

Ammothea spinosa (Hodgson, 1907)

Leionymphon spinosum Hodgson, 1907: 49–50, pl. VII, fig, 2.

Ammothea spinosa.– Child, 1994a: 12–13 [key], 27–28 [literature].

Material examined

Sta. 44 (SAM E2936, 3♂, 3♀, 3 Juv.); sta. 45 (SAM E2937, 1♂), sta. 53 (SAM E2938, 1♂ with eggs, 1♀).

Distribution

Records for this uncommon species extend from the Magellanic regions to the Antarctic Peninsula and Ross Sea in 73–1119 m. Its distribution is

distribution is scattered and inconsistent which possibly represents a collecting artefact rather than a true range of distribution.

Remarks

This small species has rather long anterior-pointing dorsomedian trunk tubercles and its ocular tubercle is slightly taller than these tubercles. It has conspicuous paired dorsodistal lateral process tubercles. The proboscis is a short cylinder and its slender cheliphores are almost as long as its proboscis. This is another species with variation between anterior and posterior propodi. The propodi of the first and second leg pairs are short, robust, and have more sole and heel spines than the slender and longer third and fourth propodi pairs.

Genus *Austroraptus* Hodgson, 1907

Habitus small, trunk compact, ovoid in dorsal aspect, without segmentation lines. Dorsum without median tubercles (except for 1 species), ocular tubercle usually low, eyes well developed. Proboscis small, shorter than trunk, distally tapered with tiny terminal diameter. Cheliphore scapes short, chelae reduced but some retain fingers in adults. Palps 5- to 8-segmented. Ovigers 10-segmented in both sexes. Tarsus very short. Propodus with 3–4 heel spines, long main claw, and short auxiliary claws often lost.

Austroraptus polaris Hodgson, 1907

Austroraptus polaris Hodgson, 1907: 54–56, pl. VII, fig. 2.– Fry & Hedgpeth, 1969: 116–117 [literature], figs. 174–186.– Child, 1994a: 31 [key], 33.

Material examined

Sta. 47 (SAM E2939, 1 ♀).

Distribution

This is another of many Antarctic genera and species with disjunct or scattered distributional records, most undoubtedly reflecting collecting situations rather than true geographic range. It is known from South Georgia, the South Shetlands, Antarctic Peninsula, Ross Sea, and a few localities in the eastern Antarctic quadrant in 50–569 m.

Remarks

Species of this genus all have very short proboscides which are usually bottle-shaped with a 'neck' which tapers to a small point. They otherwise have many of the characters of the variable genus *Achelia*. The palps often have fewer segments: 5-, 6-, or 8-segmented (this species has 6). Their trunks can have dorsomedian tubercles, but most, including this species, have none, and the chelae fingers in this species are atrophied into tiny bumps.

Family AUSTRODECIDAE Stock

This family of only two genera contains extremely small species which are predominantly Antarctic and Southern Hemisphere residents. The species in the genus represented herein all have tubular pipette-like proboscides which have rings or annulations over most of their surface. Their ocular tubercles are slender anterior-pointing cones with distal eyes. They lack cheliphores entirely. The palps originate on lateral extensions of the cephalic segment, are very long and 5-segmented, although more than one species has the distal two segments coalesced. Their ovigers are reduced to very tiny nonfunctional appendages of 1, 2, 3, 4, or 6 segments. None have been described with 5 oviger segments. The ovigers form the basis, along with the presence or absence of auxiliary claws, for dividing species into Sections for easier identification.

Genus *Austrodecus* Hodgson, 1907

Species in this genus are among the smallest of all Pycnogonida with trunk lengths of 4–5 mm. They lack cheliphores entirely as adults, and have very reduced tiny ovigers of 1 to 4, or 6 segments with few setae or none. Only one species is included in this collection.

Austrodecus glaciale Hodgson, 1907

Austrodecus glaciale Hodgson, 1907: 53, pl. VIII, fig. 1.– Child, 1994b: 54–56 [key], 63–67 [literature], fig. 6.

Material examined

Sta. 61 (SAM E2940, 1 specimen).

Distribution

This is the most common species of a predominantly Antarctic genus (Child, 1994b: 63–

67, lists 2300+ specimens). It has been collected on the Campbell Plateau of New Zealand, in the vicinity of South Georgia and in most commonly collected areas of the Antarctic continent in sublittoral depths to 2100 m.

Remarks

Austrodecus specimens are easily separated from other genera and families but difficult to separate among themselves. This is a rather generalized species among many with more or less conspicuous tubercles and other architectural characters. It has broad conical dorsomedian trunk tubercles each with 1–2 short apical setae. The proboscis is slightly longer than its rather robust palps. This group of species can sometimes be separated by use of the first coxae dorsodistal tubercles. The anterior pair of coxae have a single tubercle and the other six coxae have two in this species where first coxae tubercles vary from one to two in various combinations (all first coxae with paired tubercles, or 1: 2: 2: 1 tubercle arrangement, or 1: 1: 2: 2, and some with 1: 2: 2: 2, as in this species).

Males have a broadly pointed triangular cement gland opening at the midventral femur while most others have no triangular opening or a narrower triangular or pointed orifice. Ovigers of this genus are on both sexes and are extremely tiny and difficult to discern but this species is one of the majority having six segments. It forms the basis of the *glaciale*-section in identification keys to the genus.

Family COLOSSENDEIDAE Hoek

Many species in this family are the largest of all pycnogonids and one has a leg span of a half metre or even more. They are predominantly denizens of the deep sea and walk on extremely long slender legs. The trunk of the largest specimens may only be 3–4 cm long. Their proboscis is usually longer to much longer than the trunk. The genus *Colossendeis* lacks cheliphores entirely in adults, while the genera *Decolopoda* and *Dodecolopoda* have them. The palps are mostly very long and slender, and the extremely long ovigers have a distal curved part called a strigilis which is used to clean the long appendages. The oviger also has a terminal claw. The leg segments are slender and protracted and the distal segments merely form a slender extension of the leg. The main claw is usually quite long and auxiliaries are always lacking.

Genus *Colossendeis* Jarzynski, 1870

Species in this usually deep-sea genus are giants of the Class Pycnogonida and specimens with leg spans of 300–400 mm are common. Adults are quite slender, usually are without trunk segmentation, lack any form of cheliphores, and usually have a very long proboscis which is carried horizontally (sometimes with a distal upward or downward curve). There is a great degree of intraspecific variation among species in this genus and, unfortunately, the more specimens collected, the greater the range of variation found in most species.

Colossendeis adelpha, new species

Fig. 1

Material examined

Sta. 41, 1 holotype specimen (SAM E2941).

Distribution

Known only from station 41 in Prydz Bay, in 333–341 m.

Description

Extremely large trunk size for this genus, leg span 352 mm. Trunk glabrous. Lateral processes slightly longer than their distal diameters, separated by their diameters, glabrous. Neck very short. Ocular tubercle a small rounded truncate cone with low round anterodistal tubercle, eyes very indistinct, without pigment. Proboscis robust, little longer than trunk, distal half inflated to 1.5 times proximal stem and moderately downcurved, mouth rounded. Abdomen a small narrow cylinder not extending to distal rim of fourth leg first coxae, downcurved.

Palp robust, third segment longest, about 1.25 length of fifth segment. Distal segments short cylinders, sixth little longer than fourth, seventh through tenth each shorter than last. Armed with fields of tiny short setae distally on fifth and on dorsal surface only of distal five segments.

Oviger typical, robust, strigilis spines plain, in multiple rows, very short, distally rounded, without larger distal spine creating subchela as in other species. Terminal claw slender, well curved, about 0.66 length of terminal segment.

Leg with dorsal and distally ventral row of very short spines. First coxae with group of small rounded tubercles on dorsodistal rim, second coxae very short, little longer than first and third. Femora and second tibiae of equal length, first

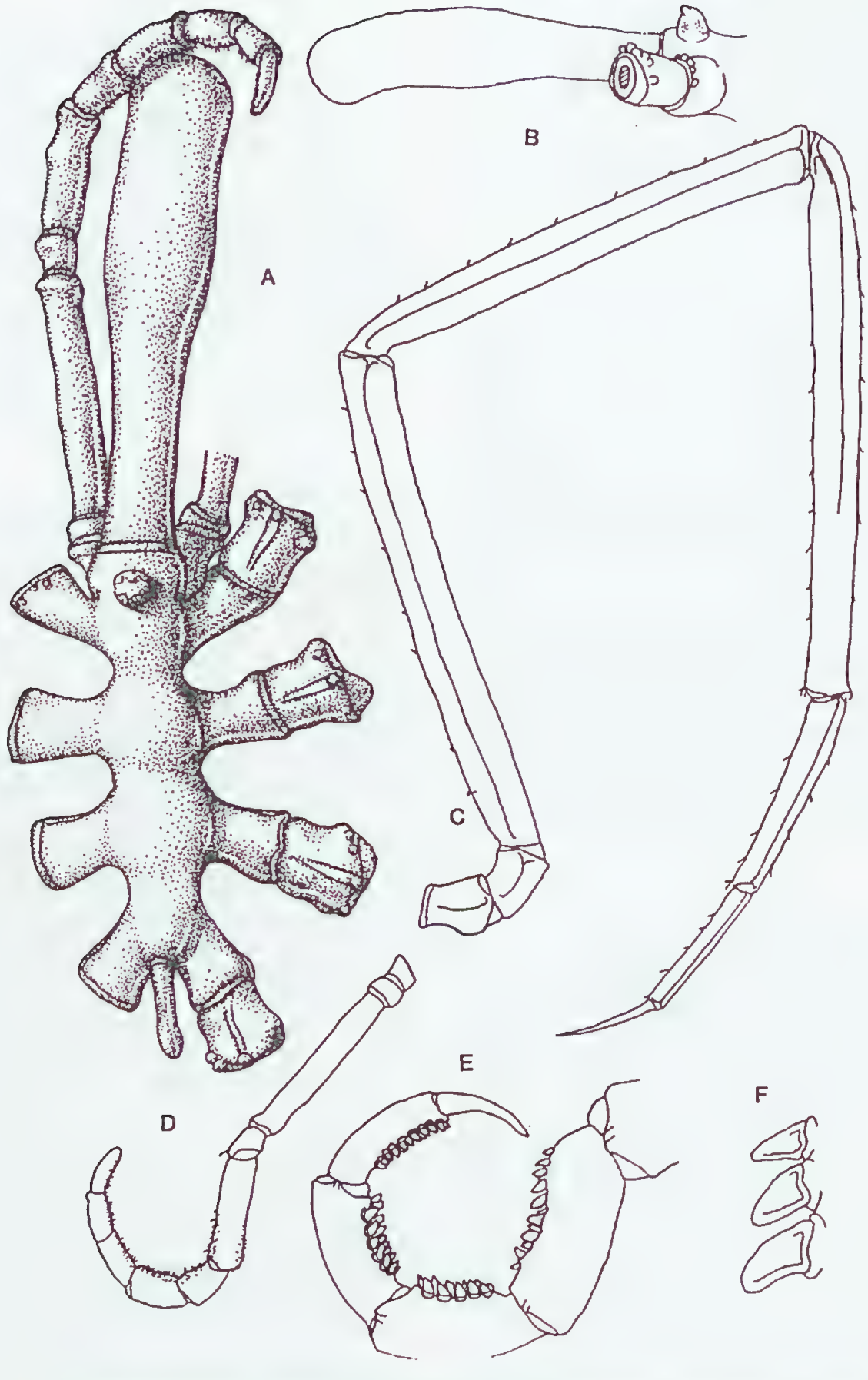

FIGURE. 1. *Colossendeis adelpha*, new species, holotype: **A**, trunk, dorsal view; **B**, trunk anterior, lateral view; **C**, third leg; **D**, palp; **E**, oviger strigilis, enlarged; **F**, three strigilis spines.

tibiae slightly shorter. Tarsus longer than propodus, with greater diameter, both segments with few tiny sole spines. Claw almost 0.66 length of propodus. Sexual pores indistinct.

Measurements of holotype in mm.

Trunk length (proboscis insertion to tip 4th lateral processes), 23; trunk width (across 2nd lateral processes), 13.4; proboscis length, 24.2; abdomen length, 4.8; third leg, 3 coxa combined, 18; femur, 39.5; tibia 1, 36.8; tibia 2, 39.5; tarsus, 16.2; propodus, 11.3; claw, 7.9.

Etymology

The species name (Greek: *adelphus*, meaning brotherly, closely related) refers to its close relationship to *C. australis* Hodgson, 1907.

Remarks

Although this species is in many characters closely related to *Colossendeis australis* Hodgson, there are several prominent differences. The proboscis of the new species is much more slender in its proximal half, is downcurved only in its distal half, and has a very rounded oral surface. That of *C. australis* is inflated to its greatest extent toward the proximal half, thus giving it a larger overall diameter. It is more or less downcurved throughout its length and has a very flat oral surface.

The palps of *C. adelpha* are quite robust and have relatively short segments in relation to each other and bear a set of tiny dorsal setules. There are no setae on the ventral surface where they are usually found. Only one other species as far as can be discerned, *C. scoresbii* Gordon, 1932, has dorsal rather than ventral setae or setules on the palps. The palps of *C. australis* are quite long, very slender in segment lengths versus diameters, and have ventral setae. The propodus and claw are both longer in relation to the tarsus in this new species than in the same segments of *C. australis*.

One of the most revealing differences is in the oviger strigilis spines. The plain spines of the new species are mostly the same size on each segment while those of *C. australis* increase in size proceeding distally on any single segment. The distal spine of the terminal segment is very large and forms a subchelate process with the adjacent claw. There is no similar chelate process on the ovigers of *C. adelpha*.

Colossendeis australis Hodgson, 1907

Colossendeis australis Hodgson, 1907: 59, pl. IX, fig. 1, pl. X, figs. 1–2.– Child, 1995b: 72–73 [key], 73–74 [literature].

Material examined

Sta. 49 (SAM E2942, 1 spec.), sta. 53 (SAM E2943, 1 spec.), sta. 57 (SAM E2944, 1 spec.), sta. 61 (SAM E2945, 11 spec.).

Distribution

This species has a scattered but almost circumpolar distribution in 143–3931 m. It has been collected in the Falkland Islands and Magellanic regions, South Georgia and South Sandwich Islands, and widely separate localities around the Antarctic continent. Its deeper collecting localities have usually been in Subantarctic basins while the shallower localities are high Antarctic.

Remarks

This species' ovigers have larger distal strigilis spines, unlike the previous species (see remarks under that species). They form a subchelate or pincer-like structure on the terminal segment, opposing the claw. Its proboscis is slightly longer than the trunk, widely inflated at midlength and, downcurved beyond this inflation. Its ocular tubercle is a broad low cone and the eyes are tiny. The distal three palp segments are subequal.

Colossendeis drakei Calman, 1915

Colossendeis drakei Calman, 1915: 11, 22–23, fig. 3.– Child, 1995b: 72–73 [key], 78 [literature].

Material examined

Sta. 41 (SAM E2946, 1 spec.), sta. 43 (SAM E2947, 1 spec.), sta. 45 (SAM E2948, 1 spec.), sta. 46 (SAM E2949, 1 spec.), sta. 52 (SAM E2950, 2 spec.), sta. 53 (SAM E2951, 6 spec.), sta. 58 (SAM E2952, 3 spec.).

Distribution

The distribution of *C. drakei* is extremely disjunct and spans an enormous depth range, suggesting that not all records involve the same species and that some have been misidentified. It has been, according to the records, collected south of Tasmania, off the Falkland Islands, South Georgia, South Sandwich, and South Shetland Islands, eastern Antarctica, and the Ross Sea. The shallowest record places it in 3 m while the deepest, 3000 m, is represented by the record from south of Tasmania.

Remarks

The most conspicuous character in this species is its unusually short proboscis which is only as long as the trunk or slightly shorter. The ocular tubercle forms a low pointed cone. Five distal segments of the palps are short, and the oviger terminal claw is also short and lacks the opposable large spine on the terminal segment. The propodus and tarsus are usually subequal and the claw is almost as long as the propodus.

Colossendeis megalonyx ssp. Fry & Hedgpeth, 1969

Colossendeis megalonyx Hoek, 1881: 67, pl. IX, figs. 1–3.

Colossendeis megalonyx ssp. Fry & Hedgpeth, 1969: 30–32, figs. 7, 8, 11–16, 23. Child, 1995b: 72–73 [key], 86–87 [literature].

Material examined

Sta. 40 (SAM E2953, 2 spec.), sta. 41 (SAM E2954, 1 spec.), sta. 44 (SAM E2955, 3 spec.), sta. 46 (SAM E2956, 4 spec.), sta. 48 (SAM E2957, 1 spec.), sta. 52 (SAM E2958, 6 spec.), sta. 53 (SAM E2959, 20+ spec.), sta. 54 (SAM E2960, ½ and 10+ spec.), sta. 58 (SAM E2961, 3 spec.), sta. 59 (SAM E2962, 2 spec.).

Distribution

The many specimens attributed to this assumed complex of subspecies come from almost all Subantarctic and Antarctic localities where collections have been made. Some specimens have been collected as far north as the vicinity of South Africa, south of Madagascar, and off South America and New Zealand. It has an enormous depth range (7–4900 m), suggesting rather definitely that more than one species is involved.

Remarks

Several subspecies were proposed for this species by Fry & Hedgpeth (1969:30–35) without adequate definition of each and with little information as a basis to separate them. The wide variation found in this genus would probably allow each subspecies to revert to its previously designated specific rank under further examination. The parent species, *C. megalonyx* Hoek, has a proboscis with little swelling and a length of little more to much longer than the trunk. One consistent character is in the palp where the eighth segment is shorter than the subequal ninth and tenth. The oviger does not have the subchelate structure of terminal spine and claw. There is very little else which conforms to a diagnosis of this species. A critical analysis of many specimens will be necessary to come to some conclusion regarding the presence or absence of valid species now found in this complex.

Colossendeis robusta Hoek, 1881

Colossendeis robusta Hoek, 1881: 66, pl. IX, figs. 4–5.– Child, 1995b: 72–73 [key], 89–90 [synonymy and literature].

Material examined

Sta. 46 (SAM E2963, 1 spec.), sta. 53 (SAM E2964, 1 spec.).

Distribution

The distribution for what is possibly another multiplicity of species under the name *C. robusta* is circumpolar in the enormous depth range of 0–3610 m.

Remarks

The most prominent characters in this species are the relatively short legs and short proboscis. The proboscis is slightly swollen medially, as long or little longer than the trunk, and the leg segments are shorter than most species in this genus. The femur and first tibia are subequal in length as are the tarsus and propodus. The distal palp segments are each unusually short, almost the same length, and armed with many tiny setae on all surfaces. The oviger strigilis lacks a chelate process of enlarged spine and claw.

Colossendeis scotti Calman, 1915

Colossendeis scotti Calman, 1915: 10 [key], 11–13, fig. 1.– Child, 1995b: 72–73 [key], 90, 92 [literature].

Material examined

Sta. 56 (SAM E2965, 1 spec.).

Distribution

This uncommon species has been collected in the vicinity of South Georgia, the South Sandwich and South Shetland Islands, Weddell Sea, and has the majority of captures located in the Ross Sea at moderate depths of 35–265 m.

Remarks

This is another species with a relatively short

proboscis, but it is widest in lateral view at the oral end and tapers toward the base. It is also quite inflated, being widest at its median length in dorsal view and constricted just before the flaring oral surface. Its eyes are darkly pigmented. The palp distal segments are quite short with the eighth shorter than the subequal ninth and tenth. The oviger strigilis has an enlarged terminal spine forming a subchelate structure with the claw. The legs are slender with the tarsus little longer than the propodus which has a long claw only slightly shorter than the propodus.

Colossendeis tortipalpis Gordon, 1932

Colossendeis tortipalpis Gordon, 1932: 12–15, figs. 2b–2e, 4a.– Child, 1995b:72–73 [key], 93 [literature].

Material examined

Sta. 53 (SAM E2966, 1 spec.).

Distribution

This species has one of the widest ranges in geographical distribution and depth of any Antarctic *Colossendeis* species. It has been collected off Tierra del Fuego, South America, off Heard Island in the southern Indian Ocean, the Scotia Sea and South Shetland Islands, and in many places in the Ross Sea. It has a vast depth range, like many *Colossendeis* species, of 44–4026 m.

Remarks

The distinctive characters of this species make it difficult to confuse with any other known Antarctic member of this genus except for *C. longirostris* Gordon, 1938. It has a very long proboscis (about 1.5 times trunk length) as in *C. longirostris*, but in this species it is downcurved with a much wider median inflation which tapers to a small oral surface. The palp has a long seventh segment, a triangular eighth segment, and the two longer distal segments are carried acutely recurved dorsally over the seventh and eighth. The oviger strigilis has a short terminal claw opposed by an enlarged distal spine on the terminal segment. There are several variations in its ocular tubercle and distal palp segments.

Colossendeis species indeterminate

Material examined

Sta. 60 (SAM E2967, 1 spec.).

Remarks

This specimen is very damaged and cannot be determined with any assurance.

Genus *Decolopoda* Eights

This genus contains the single species discussed below. It is the only 10-legged species among the Colossendeidae, at least in the Antarctic.

Decolopoda australis Eights, 1835
Fig. 2

Decolopoda australis Eights, 1835: 203–206, pl. VII.– Fry & Hedgpeth, 1969: 54–56 [early literature], Figs. 7, 8, 10, 75, 76, 78–82.– Child, 1995b: 94–95 [recent literature].

Material examined

Sta. 41 (SAM E2968, 1 spec.), sta. 42 (SAM E2969, 1 hirsute specimen), sta. 53 (SAM E2970, 1 spec.).

Distribution

This rather common species, the first Antarctic pycnogonid known, has been collected in many Subantarctic and Antarctic localities and has a circumpolar distribution. It is known from Heard Island in the southern Indian Ocean to the Ross Sea, and in a wide variety of depths from littoral to 1890 m.

Description of hirsute specimen

Entire specimen clothed in conspicuous but moderately short setae except anterior half of trunk and base of proboscis. The appendages are setose with the setae as long as but none longer than their segment diameters. Trunk setae cover the length of each lateral process in a field extending along entire dorsal surface of leg. Legs also with rows of lateral and ventral setae of various sizes. Ocular tubercle a small narrow cone with unpigmented eyes. Proboscis typical but with closely spaced setae covering all parts except base or proximal sixth of its length. Abdomen very long, slender, extending beyond second coxae distal rim of last leg pair, with dorsal field of short setae over entire length.

Cheliphores typical, with dorsal movable finger gaping above ventral immovable finger (unlike all other known pycnogonids except for following species). Both scape segments with field of dorsal

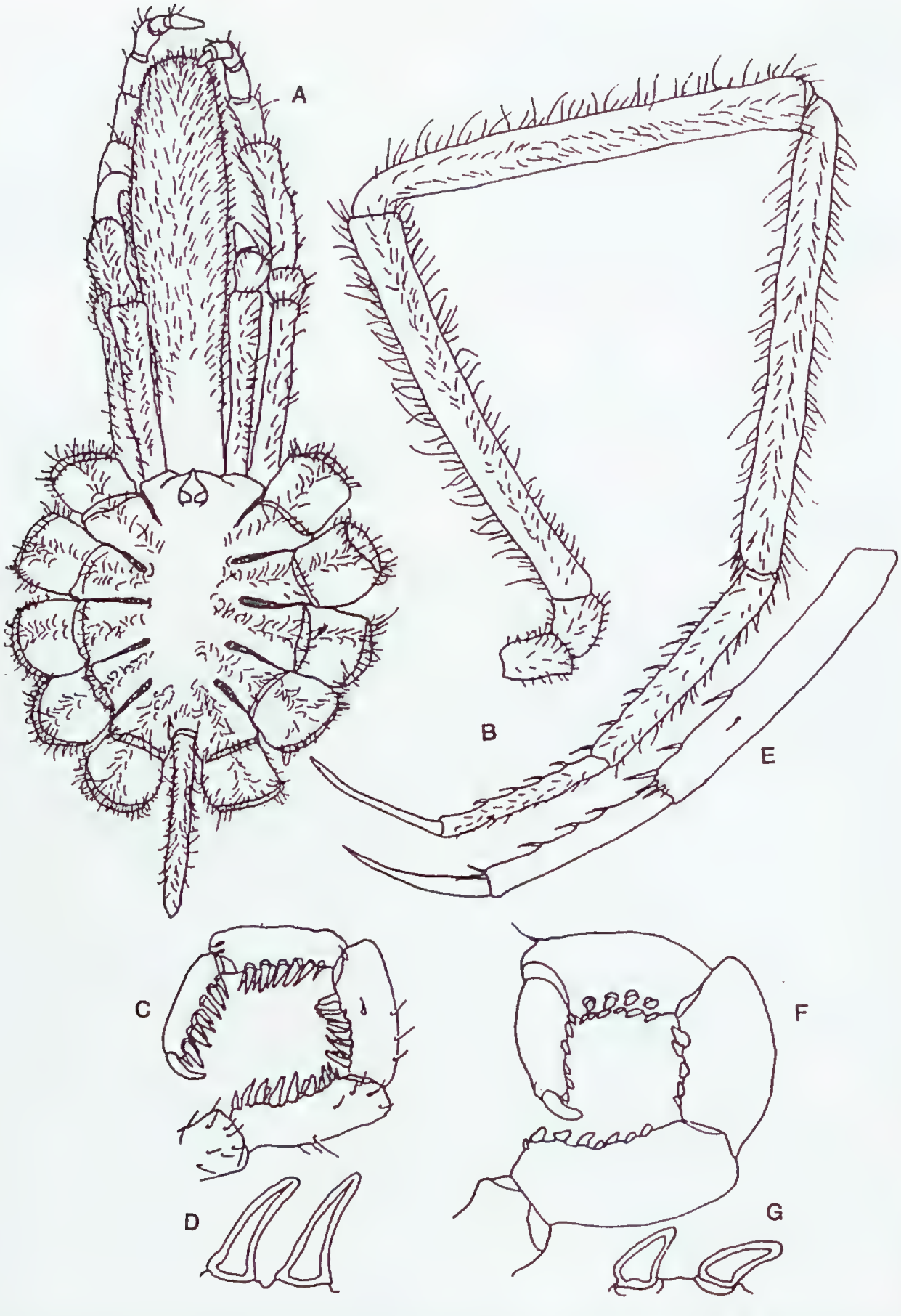

FIGURE. 2. *Decolopoda australis* Eights, the hirsute specimen: **A**, trunk, dorsal view; **B**, third leg; **C**, oviger strigilis, enlarged; **D**, two strigilis spines. Typical specimen: **E**, distal leg segments; **F**, oviger strigilis, enlarged; **G**, two strigilis spines.

setae along their lengths. Palps robust, proximal 5 segments with dorsal fields of setae, distal 5 segments with few ventral and lateral setae. Tenth segment a tapering rounded cone half length of ninth, glabrous. Ovigers decreasingly setose through their lengths. Strigilis segments slender, with rows of slightly curved plain spines each at least 3 times longer than wide. Terminal claw narrow, well curved, almost twice longer than segment diameter.

Legs slender, very setose in rows. Propodus 0.85 length of tarsus, both setose, with row of stout sole spines, but lacking ventrodistal spines. Claw very slender.

Remarks

This is the first specimen of this normally almost glabrous species to be described with extremely setose trunk, lateral processes, appendages, and proboscis. All specimens illustrated in the literature have very few setae. The differences between this specimen and typical examples of *Decolopoda australis*, besides the great number of setae, are found in the oviger strigils and the distal leg segments. The strigilis of a typical specimen is robust or even fat with very short broad plain spines, each well curved, pointing acutely distally, and little longer than their diameters. The terminal claw is shorter, measuring less than the segment diameter in length and there are only 2–3 ectal setae. The tarsus of a typical specimen is longer in relation to the propodus than that of this specimen and has fewer sole spines but does have ventrodistal spines on both segments. There are no setae on either segment of a typical specimen and the claw is usually stouter in comparison to the slender claw of this specimen. The terminal palp segment varies in typical specimens from being absent, a nub, a spike, or a full segment and is difficult to compare with the full segment of this hirsute specimen. This apparently unique specimen is possibly one of a population developing separately and might eventually become a new form, a variety, or even a new species. With the many variations known to occur in this species (causing it to have several synonyms over many years), it has maintained its status as a single species. The oviger and propodal differences are illustrated among the accompanying figures.

Genus *Dodecolopoda* Calman & Gordon

This is another genus, like the one above, with a single species which is discussed below. It is also the only 12-legged species in this collection.

Dodecolopoda mawsoni Calman & Gordon, 1933

Dodecolopoda mawsoni Calman & Gordon, 1933: 107–115, fig. 1.– Child, 1995b: 95 [literature].

Material examined

Sta. 53 (SAM E2971, 1 spec.), sta. 57 (SAM E2972, 1 spec.).

Distribution

There are probably no more than six specimens of this rare species listed in the literature, but from these scattered records, its known distribution is probably circumpolar. It is known from the South Shetland Islands, Palmer Archipelago, the Ross Sea, and in Enderby Land at 62°E. Known capture depths are 146–549 m.

Remarks

This is the first record known with two specimens of this species in one report. This is the only pycnogonid known with the paired characters of twelve legs and giant size and therefore is easily recognized. The only other known Antarctic species with twelve legs, *Sexanymphon mirabilis* Hedgpeth & Fry, 1964, is quite small.

This species is closely related to *Decolopoda australis*, and is the only other pycnogonid known with tong-like chelae having the movable finger dorsal to the immovable finger rather than a movable finger in the almost universal ventral position. Both have closely crowded lateral processes creating a circular or ovoid trunk in dorsal aspect. The long proboscis of both is distally inflated and downcurved, the legs are moderately long, the tarsus is much longer than the propodus with its shorter claw. The legs of this species are fairly setose in rows while those of *Decolopoda australis* are almost glabrous with only a few scattered spines. The size of the two specimens in hand is perhaps twice as large as specimens of *D. australis*, although size alone is not a diagnostic character.

Family CALLIPALLENIDAE Hilton

This is a diverse family with many genera, most having few species. They all share the characters of full cheliphores and chelae with fingers, often

with teeth, a lack of palps or palps of a single blunt segment, and ovigers in both sexes, with 10 segments and no terminal claw (except in genera not found in Antarctica). Only two genera were collected in Prydz Bay.

Genus *Austropallene* Hodgson, 1915

Both palps and auxiliary claws are entirely lacking in this genus. The proboscis is styliform or narrow and very tapered distally. The cheliphores are usually large to giant with the scapes tuberculate or smooth and the chelae fingers without teeth but sometimes with 1-2 notches. The trunk lacks dorsal architecture.

Austropallene brachyura (Bouvier, 1911)

Pseudopallene brachyura Bouvier, 1911: 1138.

Austropallene brachyura.– Calman, 1915: 39.– Child, 1995c: 132 [literature].

Material examined

Sta. 40 (SAM E2973, 1♂); sta. 54 (SAM E2974, 1♂).

Distribution

This is a circumpolar species known from moderate depths to 640 m.

Remarks

This is one of the more common species of this Subantarctic-Antarctic genus which contains only seven species. It is separable from others by its proboscis, a proximal cylinder with a distal cone, and small cheliphores without distal tubercles on the scapes, chelae fingers of subequal length, and smooth legs with few setae only. Gordon (1944: 36–37) provided a useful key to six of the seven species.

Austropallene calmani Gordon, 1944

Austropallene calmani Gordon, 1944: 42–45, figs. 12a, 13a–c, 14a.– Child, 1995c: 132–133.

Material examined

Sta. 45 (SAM E2975, 1♂); sta. 46 (SAM E2976, 1♂).

Distribution

Its scattered capture localities around the Antarctic perimeter make this another circumpolar species. It has been found in 163–2966 m.

Remarks

This species has a very narrow proboscis which is predominantly a cylinder. It has a small distal cone at the oral surface. The cheliphore scapes have 2–3 large dorsal tubercles and the chaela have fingers of different lengths. The immovable finger has two distal lobes into which the movable finger tip inserts. The legs have tiny tubercles bearing setae. There appears to be little variation in both this species and all others of the genus.

Austropallene cornigera (Möbius, 1902)

Pseudopallene cornigera Möbius, 1902: 186–187.

Austropallene cornigera.– Gordon, 1932: 85–86 [early literature], figs. 42–43.– Child, 1995c: 133–134 [recent literature].

Material examined

Sta. 47 (SAM E2977, 1♂).

Distribution

This extremely common circumpolar species has a moderate depth range of 90–550 m.

Remarks

This is the only species in this limited genus with giant cheliphores larger than its trunk. The immovable finger has an endal notch. The proboscis is widest at its base and tapers to a tiny distal tube. The trunk has small to large dorsomedian tubercles but they are lacking on the cheliphore scapes.

Genus *Pallenopsis* Wilson

Subgenus *(Pallenopsis)* Stock, 1975

This genus of many species has two subgenera; the first with larger numbers of more common species usually found in shallower waters, and the second with fewer deeper water species. Each has its own set of unique diagnostic characters not shared by the other subgenus. The genus *Pallenopsis* has 1-segmented palp buds, a short neck carrying ocular tubercle and cheliphores and extending dorsally over the top of the usually short proboscis. The cheliphores are sometimes 2-segmented but are progressing toward the loss of

the segmentation line dividing the two segments. The chelae are fully formed and functional. Ovigers are 10-segmented, without a terminal claw, and sometimes are only 9-segmented in females. The legs are moderately long and sometimes very long, and the male femoral cement gland is ventral and usually exits through a slender tube of varying length among the species. The propodus has auxiliary claws which are sometimes long.

The subgenus *Pallenopsis* has chelae with short fingers placed anaxially or at a right angle to the usually rectangular palm. The movable finger usually has a basal setose bump or pad in the male which is reduced in size or lacking in females. The proboscis in this subgenus is usually shorter than those of the other subgenus, *Bathypallenopsis*, and some species in this subgenus are extremely setose with some of these species having tiny lateral setules on each long seta. These setose species are almost all confined to Antarctic and Subantarctic localities. Only one has so far been collected in Prydz Bay for inclusion in this report.

Pallenopsis (Pallenopsis) patagonica (Hoek, 1881)

Phoxichilidium patagonicum Hoek, 1881: 84–86, pl. 12, figs. 6–9.

Pallenopsis patagonica.– Loman, 1923: 34.– Child, 1995c: 147–149 [literature].

Material examined

Sta. 25B (SAM E2978, 2♂); sta. 41 (SAM E2979, 3♀); sta. 42 (SAM E2980, 3♀); sta. 45 (SAM E2981, 1 juv.); sta. 46 (SAM E2982, 1♀); sta. 49 (SAM E2983, 1♂ with eggs, 1♂, 1♀).

Distribution

This is a circumpolar species found on all coasts and the deeps of Antarctica and the Subantarctic. It has an extremely wide depth range of 254–3566 m.

Remarks

This species comes close to *P. (P.) villosa* Hodgson, in being the most setose species in the subgenus *Pallenopsis*. The trunk and appendages sometimes cannot be seen for the extensive field of long setae covering its dorsal surface. The crowded setae are always plain and have no lateral setules as do those of *P. (P.) villosa*, so that the trunk shape and widely spaced lateral processes can usually be seen among the many long setae. The plain setae constitute a good diagnostic character and they are easily examined for this purpose.

Pallenopsis (P.) pilosa (Hoek, 1881)

Phoxichilidium pilosum Hoek, 1881: 90, pl. 13, figs. 10–13.

Pallenopsis pilosa Hoek, 1883: 9 [list].– Child, 1995c: 149–150 [literature].

Material examined

Sta. 41 (1♂, SAM E2984); sta. 42 (1 juv. SAM E2985); sta. 44 (1♂, with eggs, 1♂, 2♀, 1 juv., SAM E2986); sta. 45 (1♀, SAM E2987); sta. 46 (1 juv., SAM E2988); sta. 47 (3♂, 3♀, SAM E2989); sta. 49 (1♂, 2♀, SAM E2990); sta. 52 (1♂, 8♀, 1 juv., SAM E2991); sta. 53 (1♂, 4♀, SAM E2992); sta. 54 (5♂, 4♀, SAM E2993).

Distribution

This is also a circumpolar species, but it has an extremely wide depth range of 254–3566 m.

Remarks

This is one of the most setose species in the subgenus *Pallenopsis*. With the species *P. (P.) villosa* Hodgson, 1907, the trunk and appendages sometimes cannot be seen for the extensive field of long setae covering its dorsal surfaces. The multitude of setae each have many lateral setules which greatly contribute to its camouflage. This species comes close to *villosa*, but the shape of the trunk and widely spaced lateral processes can always be discerned behind the many long setae. These setae are plain and have no lateral setules, a consistent diagnostic character easily seen.

Family NYMPHONIDAE Wilson

The largest family among the nine families of Pycnogonida, this one boasts a bewildering array of some 250 species, mostly concentrated in the vast genus *Nymphon*. Many of these species fall into somewhat natural groups which are currently being recognized and used to segregate at least some of the array into manageable subsets for identification purposes. There are several other small genera in this family, only one of which was collected in Prydz Bay.

Genus *Nymphon* Fabricius, 1794

Nymphon species are often collected in large numbers from any trawl, particularly in Antarctic waters. They are characterized by having fully chelate cheliphores, palps of five segments beginning with a short first segment, fully segmented trunks with an ocular tubercle and eyes, 10-segmented ovigers in both sexes, each oviger having a fully formed strigilis with leaf-shaped denticulate inner spines and a terminal claw bearing teeth. Most shallow-water species have auxiliary claws of various lengths and more of the deep water species than not have a simple main claw without auxiliaries (for unknown reasons). Three *Nymphon* species are represented in these collections.

Nymphon australe Hodgson, 1902

Nymphon australe Hodgson, 1902: 257, pl. XI.– Gordon, 1932: 59–60 [early synonymy and literature], figs. 25d, 26b.– Child, 1995a: 9–10 [recent literature].

Material examined

Sta. 41 (SAM E2994, 1♂, 1♀); sta. 42 (SAM E2995, 1 juv.); sta. 44 (SAM E2996, 27 spec.); sta. 45 (SAM E2997, 19 spec.); sta. 46 (SAM E2998, 10 spec.); sta. 47 (SAM E2999, 5 spec.); sta. 52 (SAM E3000, 10 spec.); sta. 53 (SAM E3001, 6 spec.); sta. 54 (SAM E3002, 5 spec.); sta. 55 (SAM E3003, 3 spec.); sta. 57 (SAM E3004. 1♀); sta. 59 (SAM E3005, 1 juv.); sta. 60 (SAM E3006, 1♂, 1♀); sta. 61 (SAM E3007, 1♀).

Distribution

This species is the most commonly captured pycnogonid in Antarctic and Subantarctic waters and appears in almost every report on specimens from those waters. It has been collected as far north as Cook Strait, New Zealand, the Falkland Islands, Chilean and Argentine coasts, and some Subantarctic localities in the Indian Ocean in depths of usually less than 2000 m.

Remarks

This most common species serves as the pattern for the *Australe* group (Child, 1995a:5, 6–7 [key]) of related species in this, the largest pycnogonid genus. The group is diagnosed by a robust trunk with crowded lateral processes and a short neck which is crowded laterally with oviger bases. The trunk and lateral processes of this group of 20 described species usually have conspicuous dorsal setae or spines or both and a swollen abdomen carried horizontally. The cheliphores usually have conspicuous spines or setae only on the inner lateral surfaces. Another steady character is found in the male ovigers which almost always have fifth and sixth segments which are distally inflatable with the inflated area usually collapsed. On the legs, the tibiae and tarsus have a few long ventrodistal spines, the tarsus is as long or longer than the propodus, both are often straight and have short evenly spaced sole spines. Auxiliary claws can be absent, vestigial, or shorter than the main claw diameter, and are never longer. No other group of *Nymphon* species from the Antarctic (or any other body of water) share most of these characters. To compare morphologies, a closely related variety, *N. australe* var. *caecum* Gordon, 1944, shares all these characters but one. It is the deep-water congener of the parent species and only lacks eyes and an ocular tubercle, both of which are conspicuous and tall in *N. australe*.

Nymphon charcoti Bouvier, 1911

Nymphon charcoti Bouvier, 1911: 1138.– Child, 1995a: 35–37 [literature].

Material examined

Sta. 41 (SAM E3008, 1♂); sta. 45 (SAM E3009, 1 juv.); sta. 46 (SAM E3010, 1 juv.); sta. 52 (SAM E3011, 2♂, 1♀); sta. 53 (SAM E3012, 7 spec.); sta. 54 (SAM E3013, 3 juv.).

Distribution

This species is collected much less often than the last species listed but probably has a circumpolar range in 150–1080 m, where it appears to be common where found.

Remarks

This is the largest known species of *Nymphon* in Antarctic waters (*N. inferum* Child, 1995a, almost reaches this size). The trunk of *N. charcoti* often measures 18+ mm in length, while that of *N. inferum* has a maximum known length of about 15 mm. Both species are quite a bit larger than the average *Nymphon*.

There is a small ventrodistal knob on the anterior of the cephalic segment opposite the ocular tubercle and the short ocular tubercle has large pigmented eyes in this species. The ocular

area of *N. inferum* has a low bump and lacks eyes entirely. The tarsus is longer than the propodus in this species while it is shorter in *N. inferum*. There are a good number of similar characters in the two species besides adult size but those listed above will serve to differentiate the species.

Nymphon gracilipes Miers, 1875

Nymphon gracilipes Miers, 1875: 76.– Child, 1995a: 38–39 [literature].

Material examined

Sta. 48 (SAM E3014, 1♀); sta. 59 (SAM E3015, 1♀); sta. 60 (SAM E3016, 1♀).

Distribution

This species has been collected most often in the Indian Ocean quadrant of the Antarctic and in the Subantarctic islands to the north. It has a broad depth range of 20–1000 m, with one capture reported in 3055 m which may be either an identification or recording error.

Remarks

This clean-appearing species has a long glabrous trunk and well separated lateral processes with the same tenuosity found in the cheliphores, ovigers, and legs. The tarsus is 0.3 times longer than the propodus and the main claw is short with auxiliary claws only 0.4 as long as the main claw.

Genus *Pentanymphon* Hodgson

A very small sized species of *Nymphon* which has over time developed an extra trunk segment and an extra pair of legs making 10 in all. There is a single common species in this genus although it has sufficient variation to have caused an expanded synonymy since it was described.

Pentanymphon antarcticum Hodgson, 1904

Pentanymphon antarcticum Hodgson, 1904: 458–462, pl. XIV.– Child, 1995a: 54–55 [literature].

Material examined

Sta. 57 (SAM E3017, 1♀).

Distribution

This common species has been collected in many localities in the vicinity of 200 m, but has a scattering of other captures in depths as deep as 3227 m. It has a circumpolar distribution.

Remarks

This small species is usually very white coloured and is one of the rare pycnogonids with five pairs of legs. Its lateral processes are well separated and glabrous, the ocular tubercle and oviger bases are placed to the anterior of the first lateral processes on a long neck, and the slender long legs have few short setae.

Family PYCNOGONIDAE Wilson

This is probably the most morphologically advanced family in the pycnogonids, if advanced means loss of or reduction of segments and appendages. The species of this family and genus lack any form of cheliphores or palps, and some species have even disposed of ovigers. The males of these anovigerous species merely cement the egg clusters to their ventral trunk surfaces. Many species have also abandoned auxiliary claws or these claws are so vestigial as to be nonfunctional. The species are almost all robust with short lateral processes and very short legs with the second tibiae sometimes shorter than their diameters.

Genus *Pycnogonum* Brünnich, 1764

Pycnogonum species indeterminate

Material examined

Sta. 41 (SAM E3018, 1 larva).

Remark

This specimen is too young to be determined except to its genus.

Acknowledgments

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Appendix

Stations and Species from Prydz Bay, Antarctica,
Collected on R/V 'Aurora Australis', 1991

Sta. 25B, 68°31.1'S, 77°29.4'E, 251–416 m (bottom 450–556 m) 3 II

Achelia spicata (Hodgson)	1♀
Pallenopsis (*P.*) *patagonica* (Hoek)	2♂

Sta. 40, 67°01.1'S, 78°11.5'E, 251–260 m, trawl, 17 II

Colossendeis megalonyx ssp. Fry & Hedgpeth	2 spec.
Austropallene brachyura Hodgson	1♂

Sta. 41, 67°30.6'S, 77°14.3'E, 333–341 m, trawl, 18 I

Colossendeis adelpha, new species	1 spec.
Colossendeis drakei Calman	1 spec.
Colossendeis megalonyx ssp. Fry & Hedgpeth	1 spec.
Decolopoda australis Eights	1 spec.
Pallenopsis (*P.*) *patagonica* (Hoek)	3♀
Pallenopsis (*P.*) *pilosa* (Hoek)	1♂
Nymphon australe (Hodgson)	1♂, 1♀
Nymphon charcoti Bouvier	1♂
Pycnogonum sp. indet.	1 larva

Sta. 42, 67°34.–'S, 77°33.–'E, 300 m, trawl, 18 II

Decolopoda australis Eights	1 hirsute spec.
Pallenopsis (*P.*) *patagonica* (Hoek)	3♀
Pallenopsis (*P.*) *pilosa* (Hoek)	1 juv.
Nymphon australe (Hodgson)	1♀

Sta. 43, 67°57.5'S, 76°20.6'E, 436–441 m, trawl, 19 II

Colossendeis drakei Calman	1 spec.

Sta. 44, 68°27.9'S, 75°26.6'E, 616–622 m, trawl, 19 II

Ammothea spinosa (Hodgson)	3♂, 3♀, 3 juv.
Colossendeis megalonyx ssp. Fry & Hedgpeth	3 juv.
Pallenopsis (*P.*) *pilosa* (Hoek)	1♂ w/ eggs, 1♂, 2♀, 1 juv.
Nymphon australe (Hodgson)	27 spec.

Sta. 45, 68°58.3'S, 74°23.8'E, 787 m, trawl, 19 II

Ammothea spinosa (Hodgson)	1♂ (damaged)
Colossendeis drakei Calman	1 juv.
Austropallene calmani Gordon	1♂
Pallenopsis (*P.*) *patagonica* (Hoek)	1 juv.
Pallenopsis (*P.*) *pilosa* (Hoek)	1♀
Nymphon australe (Hodgson)	19 spec.
Nymphon charcoti Bouvier	1♂ juv.

Sta. 46, 68°31.7'S, 73°13.0'E, 743 m, trawl, 20 II

Colossendeis drakei Calman	1 spec.
Colossendeis megalonyx ssp. Fry & Hedgpeth	4 spec.
Colossendeis robusta Hoek	1 spec.
Austropallene calmani Gordon	1♂
Pallenopsis (*P.*) *patagonica* (Hoek)	1♀
Pallenopsis (*P.*) *pilosa* (Hoek)	1 juv.
Nymphon australe (Hodgson)	5 spec.
Nymphon charcoti Bouvier	1♂

Sta. 47, 68°23.1'S, 73°48.4'E, 660–662 m, trawl, 21 II

Austroraptus polaris Hodgson	1♀
Austropallene cornigera Möbius	1♂

Pallenopsis (*P.*) *pilosa* (Hoek)	3♂, 3♀
Nymphon australe (Hodgson)	5 spec.
Sta. 48, 68°03.7'S, 73°09.3'E, 680–683 m, trawl, 21 II	
Colossendeis megalonyx ssp. Fry & Hedgpeth	1 spec.
Nymphon gracilipes Miers	1♀
Sta. 49, 66°59.5'S, 76°26.7'E, 327–332 m, trawl, 22 II	
Colossendeis australis Hodgson	1 spec.
Pallenopsis (*P.*) *patagonica* (Hoek)	1♂ w/eggs, 1♂, 1♀
Pallenopsis (*P.*) *pilosa* (Hoek)	3 spec.
Sta. 52, 66°46.4'S, 72°36.5'E, 530 m, trawl, 24 II	
Ammothea adunca Child	1♂
Ammothea allopodes Fry & Hedgpeth	1♂, 2♀
Ammothea glacialis (Hodgson)	1♂
Colossendeis megalonyx ssp. Fry & Hedgpeth	6 spec.
Pallenopsis (*P.*) *pilosa* (Hoek)	1♂, 8♀, 1 juv.
Sta. 53, 66°03.7'S, 72°36.2'E, 526–532m, trawl, 24 II 91	
Ammothea glacialis (Hodgson)	1♂ w/eggs, 1♀
Ammothea spinosa (Hodgson)	1♂ w/eggs, 1♀
Colossendeis australis (Hodgson)	1 spec.
Colossendeis drakei Calman	6 spec.
Colossendeis megalonyx ssp. Fry & Hedgpeth	20+ spec.
Colossendeis robusta Hoek	1 spec.
Colossendeis tortipalpis Gordon	1 spec.
Decolopoda australis Eights	1 spec.
Dodecolopoda mawsoni Calman & Gordon	1 spec.
Pallenopsis (P.) pilosa (Hoek)	1♂, 4♀
Nymphon australe (Hodgson)	6 spec.
Nymphon charcoti Bouvier	1♂ w/eggs, 4♀, 2 juv.
Sta. 54, 67°00.3'S, 72°40.2'E, 532–536m, trawl, 24 II 91	
Ammothea glacialis (Hodgson)	1♀
Colossendeis megalonyx ssp. Fry & Hedgpeth	12½ spec.
Austropallene brachyura Hodgson	1♂
Pallenopsis (P.) pilosa (Hoek)	5♂, 4♀
Nymphon australe (Hodgson)	5 spec.
Nymphon charcoti Bouvier	3 juv.
Sta. 55, 66°43.6'S, 71°54.5'E, 667–676 m, trawl, 25 II	
Nymphon australe (Hodgson)	3 spec.
Sta. 56, 67°27.5'S, 70°20.2'E, 161–165 m, trawl, 26 II	
Colossendeis scotti Calman	1 spec.
Sta. 57, 67°16.7'S, 70°08.1'E, 172–182 m, trawl, 26 II	
Colossendeis australis Hodgson	1 spec.
Dodecolopoda mawsoni Calman & Gordon	1 spec.
Nymphon australe (Hodgson)	1 spec.
Pentanymphon antarcticum Hodgson	1 spec.
Sta. 58, 67°02.4'S, 70°18.8'E, 242–244 m, trawl, 26 II	
Colossendeis drakei Calman	3 spec.
Colossendeis megalonyx ssp. Fry & Hedgpeth	3 spec.
Sta. 59, 66°53.4'S, 70°40.5'E, 444–453 m, trawl, 27 II	
Colossendeis megalonyx ssp. Fry & Hedgpeth	2 spec.
Nymphon australe (Hodgson)	1 juv.
Nymphon gracilipes Miers	1♀

Sta. 60, 67°16.3'S, 68°57.7'E, 139 m, trawl, 28 II

Colossendeis sp. indet.	1 damaged spec.
Nymphon australe (Hodgson)	1♂, 1♀
Nymphon gracilipes Miers	1♀

Sta. 61, 67°27.4'S, 68°50.3'E, 145–150 m, trawl, 1 III

Austrodecus glaciale Hodgson	1 spec.
Colossendeis australis Hodgson	11 spec.
Nymphon australe (Hodgson)	1 spec.

References

BÖHM, R. 1879. Ueber die Pycnogoniden des Kg. Zoolog. Museums zu Berlin, insbesondere über die von S.M.S. *Gazelle* mitgeberichte Arten. *Monatsberichte der Königlichen Preussischen Akademie der Wissenschaften zu Berlin*, **1879**: 170–195.

BOUVIER, E. L. 1911. Les Pycnogonides du *Pourquoi Pas? Comptes Rendus des Séances Hebdomadaires de l'Académie des Sciences, Paris*, **152**: 1136–1142.

BRÜNNICH, M. T. 1764. 'Entomologia sistens Insectorum Tabulas Systematicas, cum Introductione et Iconibus, etc.': 1–87. Hafniae.

CALMAN, W. T. 1915. Pycnogonida. *British Antarctic (Terra Nova) Expedition, 1910.* Zoology, **3**(1): 1–74.

CALMAN, W. T. & GORDON, I. 1933. A dodecolopodous Pycnogonid. *Proceedings of the Royal Society of London* (B), **113**: 107–113.

CHILD, C. A. 1994a. Antarctic and Subantarctic Pycnogonida 1. The Family Ammotheidae. *Biology of the Antarctic Seas XXIII. Antarctic Research Series*, **63**: 1–48.

CHILD, C. A. 1994b. Antarctic and Subantarctic Pycnogonida 2. The Family Austrodecidae. *Biology of the Antarctic Seas XXIII. Antarctic Research Series*, **63**: 49–99.

CHILD, C. A. 1995a. Antarctic and Subantarctic Pycnogonida III. The Family Nymphonidae. *Biology of the Antarctic Seas XXIV. Antarctic Research Series*, **69**: 1–68.

CHILD, C. A. 1995b. Antarctic and Subantarctic Pycnogonida IV. The Families Colossendeidae and Rhynchothoraxidae. *Biology of the Antarctic Seas XXIV. Antarctic Research Series*, **69**: 69–111.

CHILD, C. A. 1995c. Antarctic and Subantarctic Pycnogonida V. The Families Pycnogonidae, Phoxichilidiidae, Endeidae, and Callipallenidae, including the genus *Pallenopsis*. *Biology of the Antarctic Seas XXIV. Antarctic Research Series*, **69**: 112–160.

CLARK, W. C. 1977. The Genus *Ammothea* Leach (Pycnogonida) in New Zealand waters: New species and a review. *Journal of the Royal Society of New Zealand*, **7**(2): 171–187.

EIGHTS, J. 1835. Description of a new animal belonging to the Arachnides of Latreille; discovered in the sea along the shores of the New South Shetland Islands. *Boston Journal of Natural History*, **1**(2): 203–206, pl. VII.

FABRICIUS, J. C. 1794. Entomologia Systematica Emendata et aucta, **4**: 416–417. Hafniae.

FRY, W. G. & HEDGPETH, J. W. 1969. Pycnogonida, 1. Colossendeidae, Pycnogonidae, Endeidae, Ammotheidae. Fauna of the Ross Sea, 7. *Memoirs of the New Zealand Oceanographic Institute*, **49**: 1–139.

GILTAY, L. 1934. Pycnogonides. Résultats du voyage de la *Belgica* en 1897–99. *Rapports Scientifiques des Résultats de la Voyage de la Belgica en 1897–99. Zoologie*: 1–16.

GORDON, I. 1932. Pycnogonida. *Discovery Reports*, **6**: 1–138.

GORDON, I. 1938. Pycnogonida. *Scientific Reports of the Australasian Antarctic Expedition* (C), (Zoology and Botany), **2**(8): 1–40

GORDON, I. 1944. Pycnogonida. *Reports of the British, Australian and New Zealand Antarctic Research Expedition*, (ser.B), **5**(1): 1–72.

HEDGPETH, J. W. & FRY, W. G. 1964. Another dodecolopodous pycnogonid. *Annals and Magazine of Natural History*, (13), **7**: 161–169.

HODGE, G. 1864. List of the British Pycnogonidea, with descriptions of several new species. *Annals and Magazine of Natural History*, (3) **13**: 113–117, pls. XII, XIII.

HODGSON, T. V. 1902. Crustacea (Pycnogonida). *In*: *Report on the Collections of Natural History made in the Antarctic Regions during the Voyage of the Southern Cross*: 256–258. London.

HODGSON, T. V. 1904. On a new pycnogonid from the South Polar regions. *Annals and Magazine of Natural History*, (7) **14**: 458–462.

HODGSON, T. V. 1907. Pycnogonida. National Antarctic Expedition 1901–1904. *Reports of the National Antarctic Expedition of 1901–1904. Natural History*, **3**: 1–72, 10 pls.

HODGSON, T. V. 1915. The Pycnogonida collected by the *Gauss* in the Antarctic regions, 1901–03. preliminary report. *Annals and Magazine of Natural History*, (ser.8) **15**(85): 141–149.

HOEK, P. P. C. 1881. Report on the Pycnogonida dredged by HMS *Challenger* 1873–76. *Reports of the Scientific Results of the Exploring Voyage of HMS* Challenger, **3**(10): 1–167, 21 pls.

HOEK, P. P. C. 1883. The Pycnogonida dredged in the Faeroe Channel during the cruise of HMS *Triton* in August 1882. *Transactions of the Royal Society of Edinburgh*, **32**(1): 1–10.

JARZYNSKY, T. 1870. Praemissus catalogus Pycnogonidarum. Inventarium in mari Glaciali, ad oras Lapponiae rossicae et in mari Albo, anno 1869 et 1870. *Annales de la Société des Naturalistes de St. Pétersbourg*, **1**: 9–13.

LEACH, W. E. 1814. The Zoology Miscellany, **1**: 33–34, 43–45. London.

LOMAN, J. C. C. 1923. Subantarctic Pantopoda from the Stockholm Museum. *Arkiv för Zoologi*, **15**(1): 9–13.

MIERS, E. J. 1875. Descriptions of new species of Crustacea collected at Kerguelen's Island by the Rev. A. E. Eaton. *Annals and Magazine of Natural History*, (4), **16**: 73–76.

MÖBIUS, K. 1902. Die Pantopoden der deutschen Tiefsee-Expedition, 1898–99. *Wissenschaftliche Ergebnisse der deutschen Tiefsee-Expedition auf dem Dampfer* 'Valdivia', *1898–1899*, **3**: 177–196.

STOCK, J. H. 1975. Pycnogonida from the continental shelf, slope, and deep-sea of the tropical Atlantic and East Pacific. Biological Results of the University of Miami deep-sea expeditions, 108. *Bulletin of Marine Science*, **24**(4): 957–1092.

VERRILL, A. E. 1900. Additions to the Crustacea and Pycnogonida of the Bermudas. *Transactions of the Connecticut Academy of Arts & Sciences*, **10**(2) (15): 580–582.

SELECTION OF LECTOTYPES AND REDESCRIPTIONS OF THREE *CISSEIS* (COLEOPTERA: BUPRESTIDAE) SPECIES

SHELLEY BARKER

BARKER, S. 1998. Selection of lectotypes and redescriptions of three *Cisseis* (Coleoptera: Buprestidae) species. *Records of the South Australian Museum* **31**(1): 21–23.

Carter (1923) described *C. elliptica* var. *frontalis*, recognised by Obenberger (1935) as a primary homonym of *C. frontalis* Kerremans and replaced with *C. carterella*. Carter (1940) synonymised *C. carteri* Obenberger with *C. elliptica* Carter. Examination of the types and a series of all three taxa shows that they are all good species. Lectotypes of the three species are selected.

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Material

Specimens examined came from the following institutions:

ANIC – Australian National Insect Collection, Canberra.
AMSA – Australian Museum, Sydney.
NMPC – National Museum Prague, Czech Republic.
NMVA – National Museum of Victoria, Melbourne.
QMBA – Queensland Museum, Brisbane.
SAMA – South Australian Museum, Adelaide.

Sub-Species Elevated To Species And Selection Of Lectotypes

Obenberger (1935) recognised *Cisseis elliptica* var. *frontalis* Carter, 1923 as a primary homonym of *Cisseis frontalis* Kerremans, 1898 and published the replacement name *C. carterella*. *C. elliptica* Carter is an arid zone Western Australian species, while *C. carterella* is found in mountainous areas in northern Queensland. A comparison of the two forms shows clearly that they are separate species on the basis of differences in morphology, male genitalia (Fig. 1) and distribution.

Carter (1923) described the taxon from two specimens, one from Kuranda, Dodd, in his own collection and the other from Herberton in QMBA. I have located the two syntypes, both are female. One is held by QMBA the other by NMVA. I hereby select the female specimen in QMBA labelled 'Herberton. C. J. Wild. Jan 91. c/2712' as the lectotype of *Cisseis carterella* Obenberger, 1935.

Two syntypes of *C. carteri* Obenberger are in NMPC. I hereby select male specimen no. 23769, Yilgarn, Western Australia as the lectotype of *Cisseis carteri* Obenberger, 1933.

Carter (1923) based his description of *Cisseis elliptica* on two specimens collected by H. W. Brown at Cue and Tenindewa. A female specimen labelled '*C. elliptica* Carter, Cue, W.A., H. W. Brown, Cotype', is lodged in the collection of the National Museum of Victoria. I hereby select this specimen as the lectotype of *C. elliptica* Carter.

Description Of Species

Cisseis carterella Obenberger, 1935
(Fig. 1 C)

Cisseis elliptica var. *carterella* Obenberger, 1935: 846 replacement name for *Cisseis elliptica* var. *frontalis* Carter, 1923, homonym of *C. frontalis* Kerremans, 1898.

Type

Lectotype: ♀, Herberton, Jan. 91, C. J. Wild, QMBA; *Paralectotype:* ♀, Kuranda, Dodd, NMVA.

Colour

Head, antennae, pronotum, scutellum ventral surface and legs shiny bronze. Elytra dark brown. Hairs white.

Shape and sculpture

Head with deep anterior median fovea; deep punctures becoming shallow posteriorly, most with single emergent seta; interocular width 0.6

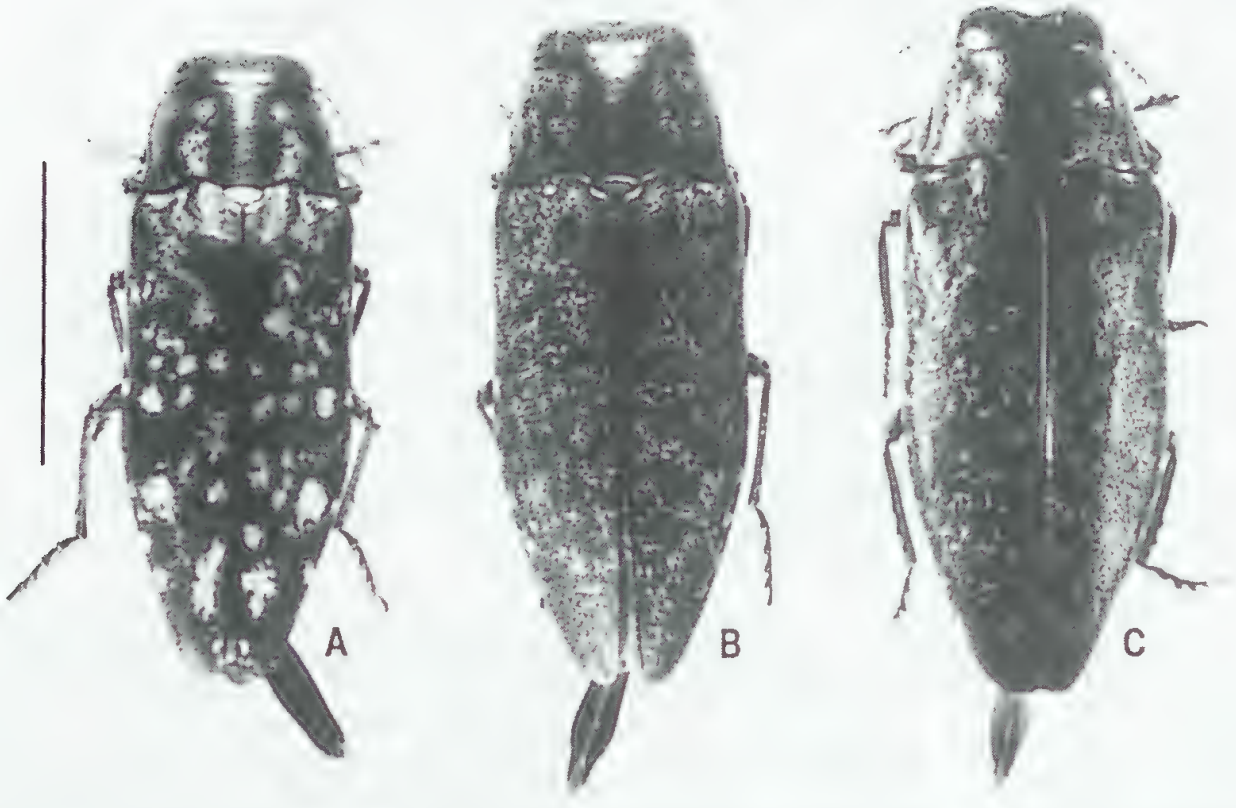

FIGURE 1. Habitus photographs of the following *Cisseis* species. A, *C. carteri* Obenberger. B, *C. elliptica* Carter. C, *C. carterella* Obenberger. Scale bar = 5mm.

head width. Antennae: antennomeres 1–3 obconic; 4–11 toothed. Pronotum: anterior margin projecting medially, basal margin sinuate; medially glabrous with shallow punctures; laterally, most punctures with single emergent seta lying in sinuous striae; dorsal carina diverging from ventral carina at base and then parallel to it, reaching apical margin, space between punctured, most punctures with emergent seta. Scutellum scutiform, laterally elongate at basal margin, glabrous, surface convex with few shallow punctures. Elytra heavily punctate with irregular clumps of hairs mostly in single row widely scattered over the surface; prominent humeral callus, apices rounded, apical margin sub-serrate. Ventral surface shallowly punctured, hairy but less so in the mid-ventral line.

Aedeagus

In *C. elliptica* (Fig. 1 B) the parameres are laterally indented just before apex and have a membranous lateral apical flange. In *C. carterella* (Fig. 1 C) the parameres are rounded laterally to apex without an apical flange.

Size

Males 11.7 x 4.7 mm (10). Females 13.2 x 5.2 mm (5)

Distribution

Queensland: Kuranda, Herberton, Mt Spec, Maryborough.

Cisseis carteri Obenberger, 1924
(Fig. 1 A)

Cisseis carteri Obenberger, 1924: 109.

Cisseis elliptica Carter, 1940: 389.

Type

Lectotype: ♂, NMPC no. 23 769, Yilgarn, W. Australia; *Paralectotype:* ♂, NMPC no. 23 770, Yilgarn, Western Australia.

Colour

Head coppery-bronze; hairs silver, rounded in males, flattened and broad in females. Antennae coppery-bronze. Pronotum bronze medially, coppery-bronze laterally; hairs flattened and broad in both sexes, in a medial column on each side diverging outwards as a basal elongate mark and a discrete round mark apically, along the upper edge of the dorsal carina and around the angle and the interval between dorsal and ventral carina. Scutellum bronze. Elytra bronze with broad flattened hairs mainly forming a large number of

small rounded spots but with a pair of elongate basal marks continuing on from thoracic line. Ventral surface and legs coppery-bronze.

Shape and sculpture

Head closely punctured, hairy, flat without medial fovea, interocular width 0.6 head width. Antennae: antennomeres 1–3 obconic; 4–11 toothed. Pronotum shallowly punctured medially, punctures deeper laterally and arranged in sinuous striae; anterior margin projecting medially, basal margin sinuate; upper carina glabrous and flattened diverging from lower carina at base then more or less parallel to it, diverging just before reaching the apical margin, interval punctured and with flattened hairs. Scutellum scutiform, basal margin convex, expanded laterally, few shallow punctures, glabrous. Elytra punctured below humeral callus and above to the pre-medial area, punctures arranged in sinuous striae, remaining part heavily wrinkled to the apex; rounded at apex; apical margin sub-serrate. Ventral surface with dense flattened hairs laterally, glabrous medially, shallowly punctured.

Size

Males, 11.4 x 4.1 mm (10). Females, 13.6 x 5.0 mm (5).

Aedeagus

Parameres heavily chitinised, more or less parallel-sided.

Distribution

Western Australia: Wurarga, Dedari.

Cisseis elliptica Carter, 1923
(Fig. 1 B)

Cisseis elliptica Carter, 1923: 170.

Type

Lectotype: ♀, Cue, W. A., H. W. Brown, NMVA; *Paralectotype*: ♂ Tendindewa, H. W. Brown, AMSA.

Colour

Head bronze, clypeus coppery. Antennae bronze with coppery reflections. Pronotum, scutellum, elytra, ventral surface and legs bronze. Hairs silver.

Shape and sculpture

Head flat, deep punctures anteriorly, becoming shallow posteriorly each with individual seta, narrow median glabrous line free of punctures on basal half; interocular width 0.7 head width. Antennae: antennomeres 1–3 obconic; 4–11 toothed. Pronotum with shallow punctures, laterally arranged in sinuous striae each with individual seta; apical margin projecting medially, basal margin sinuate; dorsal carina glabrous, diverging from ventral carina basally converging before reaching apical margin, interval punctured, each puncture with an individual seta. Scutellum scutiform, laterally expanded, basal margin convex, punctured. Elytra punctured under and over humeral callus and along suture to middle, remainder wrinkled; small clumps of bifurcate hairs (lower shorter part flat, upper longer and round) forming irregular patterns; apically rounded; apical margin sub-serrate. Ventral surface with shallow punctures each with individual seta.

Size

Males, 11.4 x 4.3 mm (6). Females, 11.8 x 4.5 mm (11).

Aedeagus

Parameres elongate, narrow with a lateral apical flange on each side. Ventral valve excised in males.

Distribution

Western Australia: Cue, Dedari, Tammin, Wurarga, Leonora.

Acknowledgments

I am endebted to the following for assistance: Dr G. B. Monteith, QMBA; Dr K.Walker & Ms Catriona McPhee, NMVA; Dr S. Bily, NMPC; Mr T. A. Weir, ANIC; Dr E. G. Matthews, SAMA; Mr M. Moulds, AMSA; Mr A. McArthur, SAMA for photography.

References

CARTER, H. J. 1923. Revision of the genera *Ethon, Cisseis* and their allies. (BUPRESTIDAE). *Proceedings of the Linnean Society of New South Wales* **48:** 159–176.

CARTER, H. J. 1940. Australian Buprestidae and the Junk Catalogue. *Annals and Magazine of Natural History* series 11 no **6:** 380–389.

KERREMANS, C. 1898. Buprestides nouveaux de l'Australie et des régions voisines. *Annales de la Société Entomologique de Belgique* **42:** 113–182.

OBENBERGER, J. 1924. Kritische Studien über die Buprestiden (Col.). *Archiv für Naturgeschichte* **90,** 3 Abt. A Heft: 1–171.

OBENBERGER, J. 1935. BUPRESTIDAE III. Pp 787–934 *in* 'Coleopterorum Catalogus'. W. Junk: The Hague.

THE SPECIES OF *ANTROPORA* NORMAN, 1903 (BRYOZOA: CHEILOSTOMATIDA), WITH THE DESCRIPTION OF A NEW GENUS IN THE CALLOPOROIDEA

KEVIN J. TILBROOK

TILBROOK, K. J. 1998. The species of *Antropora* Norman, 1903 (Bryozoa: Cheilostomatida), with the description of a new genus in the Calloporoidea. *Records of the South Australian Museum* **31**(1): 25–49.

The cheilostomate bryozoan genus *Antropora* was introduced by Norman (1903b) for *Membranipora granulifera* Hincks, 1880a. The need for a review of the genus *Antropora* became apparent during the course of a current study of reef-associated bryozoans collected from localities in the south-west Pacific. This paper redescribes *Antropora granulifera* (Hincks, 1880a) and stabilises the taxon through the selection of a neotype specimen. In all, seven species of *Antropora* are described and figured: *A. granulifera*, *A. minor*, *A. subvespertilio*, *A. tincta*, *A. marginella*, *A. typica* and *A. erectirostra* new species. The new genus *Parantropora* is introduced and distinguished from *Antropora*. The type species *Parantropora penelope* new species, is described, together with the new combination, *P. laguncula*. Two further species, *Retevirgula aggregata* and *Crassimarginatella papulifera*, are described from material originally assigned to a species of *Antropora*. The classification of *Antropora* and *Parantropora* is discussed in relation to several calloporoidean families.

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The cheilostomate bryozoan genus *Antropora* was introduced by Norman (1903b) for *Membranipora granulifera* Hincks, 1880a, described originally from Madeira. Norman (1903b) was clearly familiar with Hincks' species, noting that it was commonly dredged from shell gravel off Madeira, at depths of 70–100 fathoms. *Antropora granulifera* forms encrusting unilaminar sheets; autozooids display a simple morphology, with negligible gymnocyst, moderate cryptocyst and lack spines. Small interzooidal avicularia are present; embryos are brooded in endozooidal ovicells and interzooidal communication is achieved through basal pore chambers.

Harmer (1926) was the first modern authority to make use of *Antropora* Norman, describing *A. granulifera* from material collected in the Indo-Malaysian region by the 'Siboga' Expedition (1899–1900). Harmer reviewed published records of *Membranipora granulifera* Hincks, and showed its distribution to range from Madeira and the Cape Verde Islands (Calvet 1907), to the Red Sea (Waters 1898), Sri Lanka and southern India (Thornely 1905; 1912). *Membranipora marginella* Hincks, 1884, from the Mergui Archipelago, west Thailand and also recorded subsequently from the Red Sea (Waters 1898), was also assigned to *Antropora* by Harmer (1926). Canu and Bassler (1929) published a generic diagnosis of *Antropora* based on the work of Hincks (1880a), Norman (1903b), and Harmer (1926) and reproduced their figures of the type species but did not list further records of it. Hastings (1930) reported both *A. granulifera* and *A. marginella* from various localities in the Panama Canal area.

Subsequent to Hastings (1930) *Antropora* and its type species have been ascribed an almost pan-tropical distribution and the taxonomic identity of both have become blurred. Additional confusion has been promoted by the introduction and usage of two similar genera, *Dacryonella* Canu and Bassler, 1917 and *Membrendoecium* Canu and Bassler, 1917. *Dacryonella* was introduced for the Eocene fossil *D. octonaria* Canu and Bassler, 1917, but Recent *D. typica* Canu and Bassler, 1928a, was later described from the Gulf of Mexico. In the same work Canu and Bassler (1928a) also described a new species, *Antropora pustulata*, which they stated differed from *A. granulifera* in the presence of an extensive gymnocyst, six distal spines, sporadic kenozooids and hyperstomial ovicells, all characters which demonstrate that this species clearly does not belong in *Antropora*. Later Canu and Bassler

(1929) described from the Philippines and assigned to the genus *D. minor* (Hincks, 1880b), *D. ogivalina* sp. nov., *D. trapezoides* sp. nov. and *D. subvespertilio* sp. nov. *Membrendoecium* was introduced for *Amphiblestrum papillatum* Busk, 1884, by Canu and Bassler (1917) who later (Canu and Bassler 1929) assigned to the genus *M. savarti* (MacGillivray, 1890), *M. ovatum* sp. nov., *M. lagunculum* sp. nov. and *M. japonicum* sp. nov. from the Philippines and *M. claustracrassum* from the Galapagos Islands (Canu and Bassler, 1930). Neither genus has won acceptance by subsequent authors although Marcus (1937) described *Membrendoecium leucocypha* sp. nov. from Curaçao. Silén (1941) placed *Membrendoecium* in the synonymy of *Antropora* and Osburn (1950) was unable to distinguish between *Antropora*, *Dacryonella* and *Membrendoecium*.

Cook (1968a) provided a diagnosis of *Antropora* and discussed the constitution of the genus and the work of the previous authors. She rejected *Membranipora nigrans* Hincks, 1882 and *Membranipora marginella* Hincks, 1884, both assigned to *Antropora* by Harmer (1926) and re-examined specimens attributed to both *A. granulifera* and *A. marginella* by Harmer, questioning the determinations of several of them. Cook (1968a) also noted the similarity between *Amphiblestrum papillatum* Busk, 1884, and *Membranipora trifolium* var. *minor* Hincks, 1880b, suggesting that they were congeneric.

The need for a review of the genus *Antropora* became apparent during the course of a current study of reef-associated bryozoans recently collected from Vanuatu, from Fiji and from several localities on the Great Barrier Reef. Specimens of a species attributed to *Antropora granulifera* by Ryland and Hayward (1992) were seen to be quite distinct from those figured by Ristedt and Hillmer (1985) as the same species and from those described by Cook (1968a) and Mawatari and Mawatari (1981). This paper redescribes *Antropora granulifera* (Hincks, 1880a) and stabilises the taxon through the selection of a neotype specimen. Type and original published material of all of the other species redescribed herein have been re-examined. Six species of *Antropora* are described and figured, including *Antropora erectirostra* new species. The new genus *Parantropora*, type species *Parantropora penelope* new species, is distinguished from *Antropora* by the lack of discernible dietellae, the presence of lateral-wall septula and the occurrence of very large spatulate vicarious avicularia. The systematic status of the two genera is discussed in relation to several other speciose and taxonomically difficult calloporoidean families.

All material examined is listed; holding institutions are indicated by the following abbreviations: NHM – Zoology Department, The Natural History Museum, London; USNM – Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, Washington DC.

Systematics

The taxonomic order is based on that adopted by Hayward and Ryland (1995) as advocated by Gordon (1984; 1986; 1989). Generic and specific taxonomic diagnoses are given; the descriptions and measurements are based on the examined specimens. The synonymies for each taxon and lists of examined material are deliberately extensive due to the review nature of the paper.

Class Gymnolaemata Allman, 1856

Order Cheilostomatida Busk, 1852

Suborder Neocheilostomatina d'Hondt, 1985

Superfamily Calloporoidea Norman, 1903a

Genus *Antropora* Norman

Antropora Norman, 1903b: 87.

Antropora: Harmer, 1926: 232; Canu and Bassler, 1929: 93; Marcus, 1937: 50; Silén, 1941: 43; Osburn, 1950: 51; Cook, 1968a: 137; Mawatari and Mawatari, 1981: 25; Gordon, 1986: 37; Ryland and Hayward, 1992: 229.

Membrendoecium Canu and Bassler, 1917: 17.

Membrendoecium: Canu and Bassler, 1929: 28; Marcus, 1937: 124.

Dacryonella Canu and Bassler, 1917: 28.

Dacryonella: Canu and Bassler, 1928a: 56; Canu and Bassler, 1929: 130.

Generic diagnosis

Colony encrusting, unilaminar or multilaminar. Autozooidal cryptocyst moderately developed around the opesia, gymnocyst negligible or absent. Spines absent. Small interzooidal avicularia present. Large autozooidal-sized vicarious avicularia may be present. Ovicells endozooidal,

presence generally indicated by a slight cap-like thickening at the distal end of the autozooid. Basal pore-chambers (dietellae) present.

The vicarious avicularia are similar in size to autozooids; rostrum broadly triangular, narrowing distally, its lateral walls raised, projecting medially. Opesia of avicularium continuous, almost circular proximally, surrounded by a narrow granular cryptocyst, the junction with the distal part indicated by small proximally pointing condyles; distal part of opesia extending almost the entire length of the rostrum, a slight oral shelf is apparent distally; mandible wide, slightly pointed distally.

Type species

Membranipora granulifera Hincks, 1880a.

Remarks

Much of the confusion surrounding the identity of the type species, *Membranipora granulifera* Hincks, seems to stem from Harmer's (1926) account, which was clearly based on several different species. Neither Hincks (1880a) nor Norman (1903b) described colony form in *Antropora granulifera* and both considered that it was morphologically variable, but there is no doubt that they described the same species. Canu and Bassler (1929) reproduced Hincks's (1880a) original figure, as well as those of Norman (1903b) and Harmer (1926), adding a magnification to that of Hincks, but there is no indication that they examined any of the material described by these authors. The lack of any acceptable type material of *M. granulifera* certainly contributed to the confusion surrounding its taxonomic identity and selection of a neotype (see below) to stabilise the taxon will finally resolve the problem.

The interzooidal avicularia of *A. granulifera* are the most distinctive feature of the species and the most distinctive of any species of *Antropora*. Both Hincks (1880a) and Norman (1903b) gave unambiguous descriptions, noting that their position at the distal corners of the autozooids, with rostra directed medially and almost touching at their distal tips, was constant in all the specimens they examined. Of recent authors, only Ristedt and Hillmer (1985) have noted this feature and correctly identified their material. Harmer (1926) based his description on a suite of specimens from the 'Siboga' expedition, around the Philippines and Indonesia, and on specimens from Ceylon and Japan in the collections from the Zoology Museum, Cambridge. He noted that 'adventitious' avicularia were directed distally or transversely and although he stated that three of the specimens he examined (NHM 1928.3.6.47., Mindanao; NHM 1928.3.6.48., Kei Islands; NHM 1936.12.30.5., Ceylon) agreed with Hincks's original description of *A. granulifera*, and are clearly the same species, he included other specimens which are not actually attributable to *A. granulifera*. Harmer (1926) described these latter specimens with vicarious avicularia, including those from Japan (NHM 1928.9.13.16,17.) as 'young type' colonies, which in fact are attributable to *A. typica*.

Although Mawatari and Mawatari (1981) describe and figure vicarious avicularia in *Antropora granulifera*, no evidence of these structures can be seen in either the Neotype specimen or other specimens of *A. granulifera sensu stricto*. Despite *A. granulifera* itself not producing vicarious avicularia, several other species of *Antropora* do and the generic diagnosis has been amended to take account of this fact.

Gordon (1986) amended the generic description of *Antropora* to include *Antropora pacifera* sp. nov. from New Zealand. However, this species appears to be a member of the genus *Alderina* and so the generic amendment should not be accepted.

Several Recent species allegedly attributable to *Antropora* Norman have not been covered in this paper, mainly due to the lack of type material available for examination; these are as follows:

Dacryonella levigata Canu and Bassler, 1927: 6, pl. 2, figs 7,8.

Membrendoecium compressum Osburn, 1927: 124, figs 1,2; Osburn, 1940: 358 (as *Canua* (*Membrendoecium*) *compressum*).

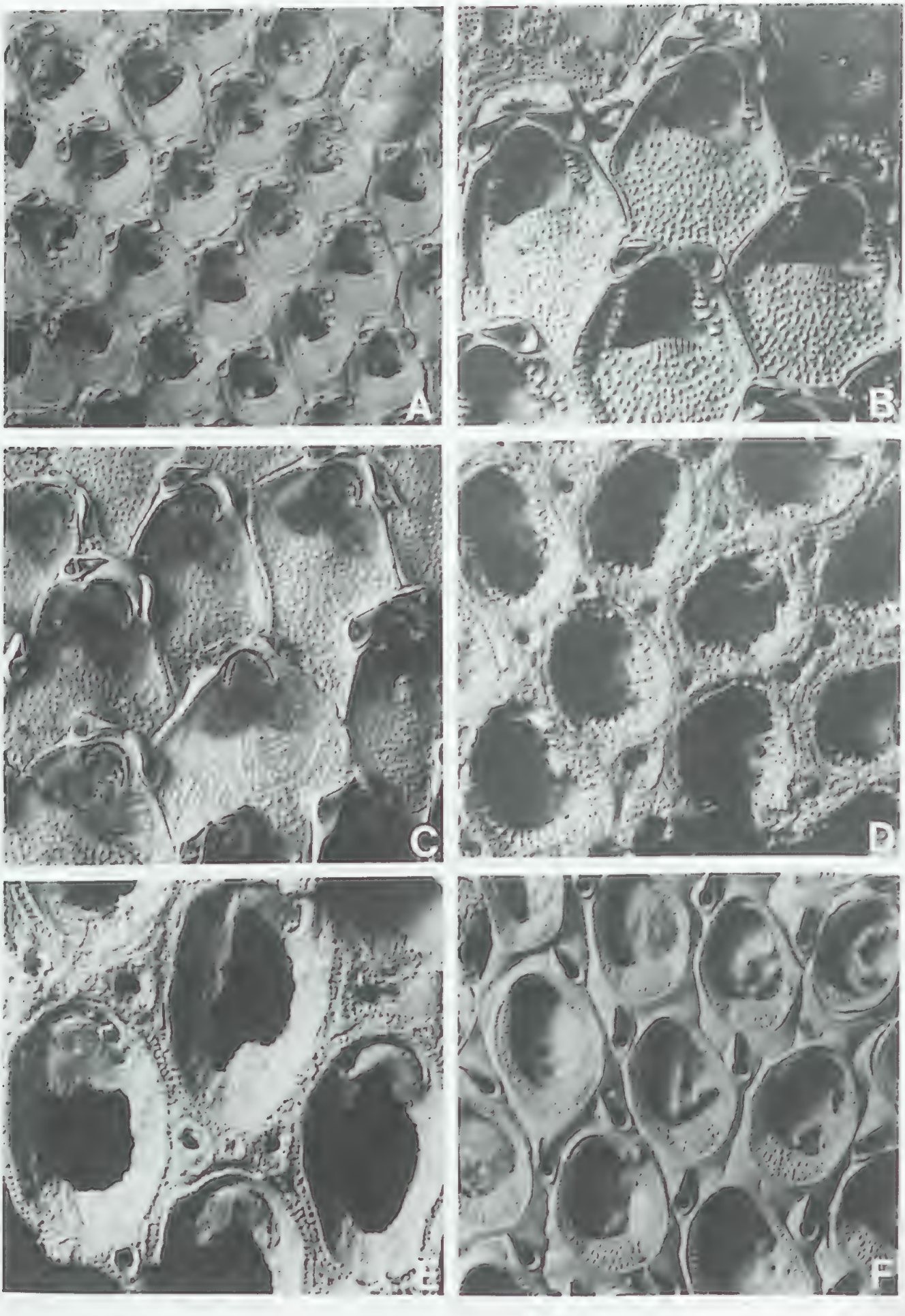
Membrendoecium parvus Canu and Bassler, 1928b: 4, 61, pl. 1, figs 1,2.

Crassimarginatella leucocypha Marcus, 1937: 46, pl. 8, fig. 20 A; pl. 9, figs 20 B,C; Rucker, 1967: 819, fig. 12c (as *Antropora leucocypha*); Mawatari and Mawatari, 1981: 29, fig. 3 (as *Antropora leucocypha*).

Antropora erecta Silén, 1941: 44, figs 56, 57; Mawatari and Mawatari, 1981: 27, fig. 1.

Antropora granulifera (Hincks, 1880a)
(Fig. 1A)

Membranipora granulifera Hincks, 1880a: 72, pl. 9, fig. 4.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Membranipora granulifera: Waters, 1898: 659, 668; Thornely, 1912: 143.

Amphiblestrum granulifera Thornely, 1905: 110.

Antropora granulifera Norman, 1903b: 87, pl. 8, fig. 4.

Antropora granulifera: Harmer, 1926: 232 (in part), pl. 14, figs 11–14; Hastings, 1930: 714; Osburn, 1940: 358; Osburn, 1950: 52, pl. 9; Cook, 1968a: 138, fig. 9; Cook, 1968b: 149; Mawatari and Mawatari, 1981: 28 (in part), fig. 2; Ristedt and Hillmer, 1985: pl. 1, fig. 3; Cuffey, 1987: 506, fig. 168.

not *Antropora granulifera*: Ryland and Hayward, 1992: 229, fig. 2c.

Dacryonella trapezoides Canu and Bassler, 1929: 133, pl. 14, figs 2,3.

Material examined

Neotype, here chosen: NHM 1919.6.25.23., Madeira, Norman Coll.

Other material examined: NHM 1919.6.25.24., Madeira, Norman Coll.; NHM 1879.5.28.6., Madeira, Rev. R. B. Watson; NHM 1879.5.28.11., Madeira, Rev. R. B. Watson; NHM 1911.10.1.628., Madeira, 25–70 feet; NHM 1882.10.18.125–138., Darros Id, Amirante Is, 22 fathoms, HMS Alert; NHM 1903.1.29.10,11., Fuafatu, Funafuti, 60 fathoms; NHM 1928.3.6.47., Siboga Stn 133, Lirung, Talaut Is, S. of Mindanao. 0–36m; NHM 1928.3.6.48., Siboga Stn 257, Kei Is, 0–52m; NHM 1928.9.13.15., Ceylon (Sri Lanka); NHM 1929.4.26.81., Jicaron Islands, St George Coll.; NHM 1936.12.30.5., Ceylon (Sri Lanka), L. R. Thornely; NHM 1970.8.4.23., Calypso Coll., Stn P.7, 6m; NHM 1997.10.6.4., Iririki Island, Vanuatu; USNM 7936., (Cotypes of *D. trapezoides*. 2 pieces) Alb. Sta. 5151, off Sirun Id, Tawi-tawi Is, Philippines. 24 fathoms; NHM 1931.12.30.43,44., (Topotype of *D. trapezoides*.) Alb. Sta. 5151, off Sirun Id, Tawi-tawi Is, Philippines. 24 fathoms. (exc. USNM).

Description

Colony forming flat, unilaminar sheets. Autozooids irregularly polygonal to hexagonal in fairly distinct alternating longitudinal rows, separated by discernible grooves. Frontal surface bordered by a crenulated mural rim, raised particularly to the distal end of the autozooid. Gymnocyst proximal, very reduced or negligible; cryptocyst occupying generally less than one half of total autozooid length, flat or very slightly convex, coarsely beaded. Opesia roughly triangular to slightly trifoliate, constricted at the proximal edge of the operculum opening. Distal to each autozooid a pair of medium-sized triangular, interzooidal avicularia. Rostra raised and acute to frontal plane, directed medially, often touching at the midline, or rarely very slightly disto-medially, particularly in ovicellate zooids; mandibles long and acutely triangular. Ovicell endozooidal, small, indistinct.

Mature dried colonies are chocolate brown in appearance, lighter and more translucent at the growing edge. The opercula are slightly darker than the rest of the frontal membrane. Cook (1968a) describes the opercula of fertile zooids as showing a slight dimorphism, i.e. wider and darker in colour than other autozooids.

FIGURE 1. **A**, *Antropora granulifera* (Hincks, 1880a), Neotype specimen NHM 1919.6.25.23., Madeira. Group of autozooids. x27. **B**, *Antropora subvespertilio* (Canu & Bassler, 1929), NHM 1912.12.22.12., Grapples Bank, Puerto Rico. Group of autozooids at the growing edge of the colony with paired distal avicularia and trifoliate opesia. x72. **C**, *Antropora subvespertilio* (Canu & Bassler, 1929), NHM 1912.12.22.12., Grapples Bank, Puerto Rico. Group of zooids with frontal membrane intact, note the wider operculum in the ovicellate zooids. x45. **D**, *Antropora tincta* (Hastings, 1930), Paratype specimen NHM 1929.4.26.72., Gorgona, Colombia. Group of autozooids, the interzooidal angles filled with either small rounded kenozooids or small interzooidal avicularia. x63. **E**, *Antropora tincta* (Hastings, 1930), Paratype specimen NHM 1929.4.26.72., Gorgona, Colombia. Group of autozooids, showing the size of the interzooidal kenozooids and avicularia and zooidal opercula. x108. **F**, *Antropora typica* (Canu & Bassler, 1928a), NHM 1928.9.13.16., Okinose, off Tokyo, Japan. Group of autozooids showing the position of the teardrop-shaped interzooidal avicularia and the extensive gymnocyst. x63.

Measurements (mm): mean±standard deviation

Specimen	n	Autozooid Length	Autozooid Width	Opesial Length	Opesial Width	Avic. Length
NHM 1919.6.25.23. Neotype.	25	0.56±0.06	0.41±0.03	0.28±0.05	0.23±0.06	0.16±0.05
Cook (1968a)	–	0.40–0.58	0.27–0.40	0.20–0.32	–	0.11–0.15
C and B (1929) (*D. trapezoides*)	–	0.55	0.45	0.20–0.22	0.20–0.25	–
NHM 1997.10.6.4.	25	0.60±0.08	0.52±0.06	0.30±0.02	0.26±0.06	0.14±0.02

Remarks

Antropora granulifera is especially characterised by the presence of two medially directed avicularia, often touching at the midline, at the distal end of every autozooid. *A. granulifera* has been reported from the warm-temperate eastern Atlantic, from the tropical eastern Pacific and from numerous localities in the Indo-West Pacific, but the taxonomic identity of the species has not been adequately reviewed.

Hincks's (1880a) description of this species is very accurate, but seems to have been overlooked by subsequent authors. Harmer's (1926) later account of *A. granulifera* seems to have caused confusion; many of the specimens he described clearly do not belong to this species, as noted by Powell (1967) and Cook (1968a). For the stabilisation of the taxon, and in the absence of the original holotype specimen, there is justification in selecting a neotype specimen, from Madeira, the type locality. No extant specimens are known from the collection of T. H. Hincks, but a Norman Collection specimen from Madeira, NHM 1919.6.25.23., is clearly the same species as that figured by Hincks (1880a) and is accordingly here selected as neotype.

Canu and Bassler (1917) erected a new genus *Dacryonella*, and later (Canu and Bassler 1929) described *D. trapezoides* sp. nov. from the Philippines; examination of type series material of *Dacryonella trapezoides* shows it to be indistinguishable from *Antropora granulifera*. (The USNM cotype specimens are heavily calcified and very abraded, but have very similar proportions to the neotype specimen of *A. granulifera*.)

Cook (1968a) examined *A. granulifera* specimens from the Canary Islands and several stations off West Africa and was confident that this material represented a single species, noting that in all characters other than size it was similar to material from the Indo-Pacific; material from the Indo-Pacific having larger zooids than that from Panama, Madeira and West Africa.

The account of *A. granulifera* by Mawatari and Mawatari (1981) and their fig. 2, leaves a certain doubt as to the true identity of the specimens they were describing. They described the presence of vicarious avicularia, illustrating a mandible, and the interzooidal avicularia are far smaller relative to the size of the autozooid, than in specimens of *A. granulifera* examined here. Two specimens from Japan (NHM 1928.9.13.16,17.) and one from Malaysia (NHM 1928.3.6.49.), in the Natural History Museum, London, formerly referred to *A. granulifera* are here regarded as belonging to *A. typica* (below). Two further specimens, from Aden (NHM 1966.1.2.3.) and Muscat (NHM 1981.2.6.1.) respectively, contain shell debris which shows no evidence of *A. granulifera*, but instead is encrusted by a mixture of *A. tincta* and *A. minor*. The species figured by Ryland and Hayward (1992) is not *A. granulifera*; however, as their specimen has not been available for examination, no specific designation can be given.

Norman (1903b) describes and figures three pairs of dietellae and several, usually four, 'lucid spots' in the basal wall, similar to those seen in *A. typica*.

Distribution

Madeira; Cape Verde Is; Indian Ocean; Ceylon (Sri Lanka); Malaysia; Philippines; Iririki Island, Vanuatu; Hawaii; Jicaron Id, Panama; Secas Is, Panama; Gulf of Panama; Petatlan Bay, Mexico; Puerto Rico; Bermuda.

This species is found in warm temperate and tropical waters globally. The record from Japan must be considered unsubstantiated.

Antropora subvespertilio (Canu and Bassler, 1929)
(Fig. 1B,C)

Dacryonella subvespertilio Canu and Bassler 1929: 134, pl. 14, fig. 1.

Measurements (mm): mean±standard deviation

Specimen	n	Autozooid Length	Autozooid Width	Opesial Length	Opesial Width	Avic. Length
C and B (1929) *D. subvespertilio*	–	0.35	0.40–0.45	0.19	0.11	–
NHM 1912.12.22.2.	30	0.53±0.06	0.43±0.04	0.22±0.02	0.18±0.01	0.15±0.01

Material examined

Holotype: USNM 7937, Alb. Sta. 5179, off Romblon Light, Romblon, Philippines, 37 fathoms.

Other material examined: NHM 1912.12.22.2. (as *Antropora granulifera*), Grapples Bank, SE corner of Puerto Rico, 124–142 fathoms.

Description

Colony unilaminar, encrusting. Autozooids distinct, broad, separated by shallow grooves. Frontal membrane bordered by thin, rounded mural rim. Gymnocyst negligible; cryptocyst, extensive, below mural rim, finely granular, somewhat convex. Opesia trifoliate, less than half frontal area, the proximal border convex with two lateral opesiular indentations, rather deep and rounded, with crenellate edges. Distal to each autozooid, two small, triangular interzooidal avicularia, directed medially, often touching, or slightly disto-medially, particularly in ovicellate zooids; rostrum slightly raised, acutely pointed distally, rounded proximally; two small articulatory condyles; mandibles acutely triangular, slightly recurved. Ovicells endozooidal, small, smooth, cap-like. Operculum of ovicellate zooids wider than autozooids, closing the ovicell.

Remarks

Antropora subvespertilio, originally described from the Philippines, is easily identified by the presence of the two medially directed avicularia distal to each autozooid and the possession of lateral, opesiular indentations of the cryptocyst, giving the characteristic trifoliate opesia.

Specimen NHM 1912.12.22.2., from Puerto Rico, originally assigned to *A. granulifera*, is undoubtedly the above species when compared with the type specimen from the Philippines. This mistaken attribution is understandable as in the dried specimen of *A. subvespertilio* the shape of the opesia is hidden by the opaque frontal membrane.

Distribution

Philippines and Puerto Rico.

Antropora tincta (Hastings, 1930)
(Fig. 1D,E)

Crassimarginatella tincta Hastings, 1930: 708, pl. 5, figs 16–19; pl. 17, fig. 120.

Antropora tincta Osburn, 1950: p. 54, pl. 4, fig. 7; pl. 29, figs 7,8.

Antropora tincta: Cook, 1968a: 140, fig. 11; Cook, 1968b: 150; Mawatari and Mawatari, 1981: 34, fig. 4; Hayward, 1988: 276, fig. 2f.

Material examined

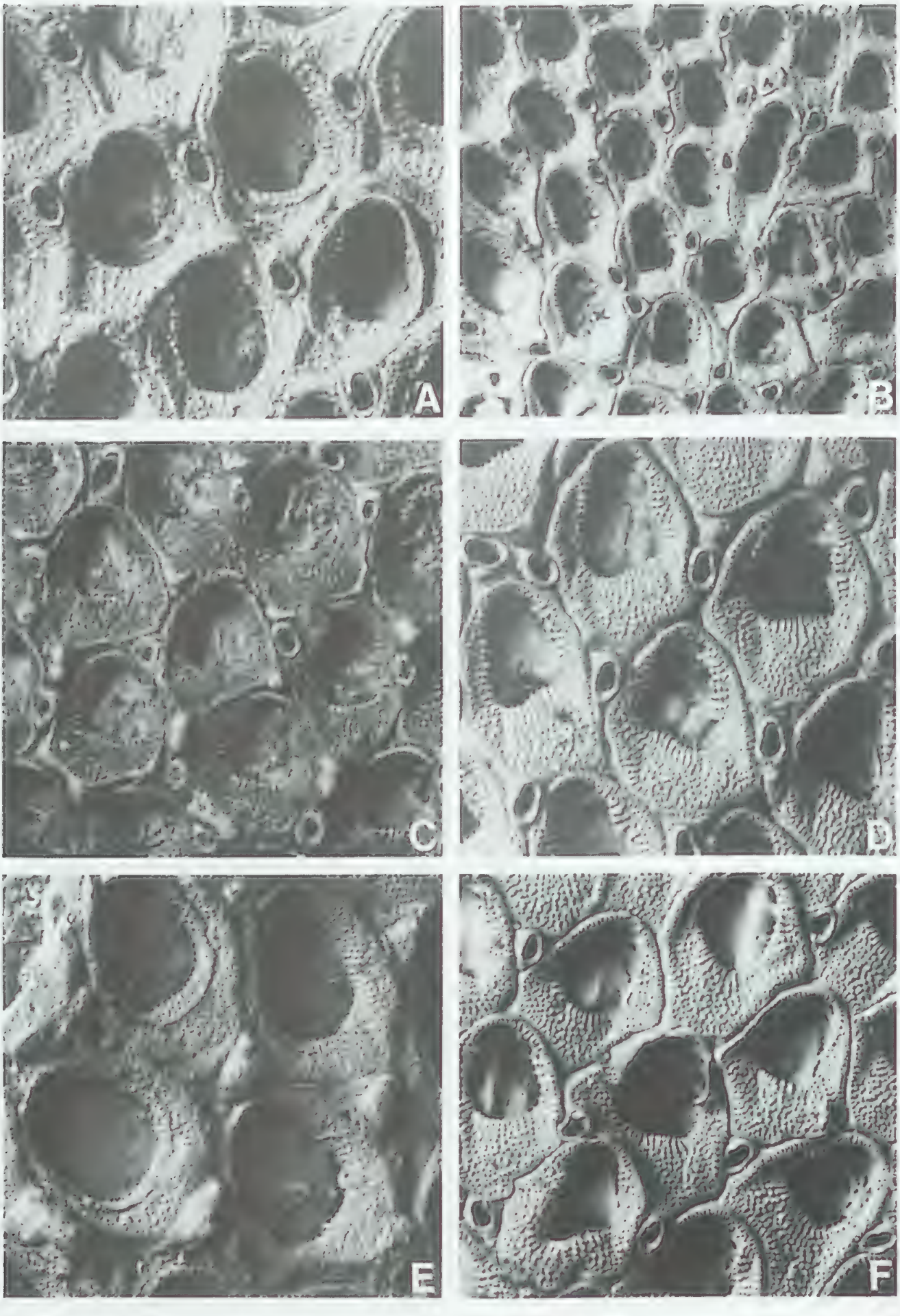
Paratype: NHM 1929.4.26.72. (part), Gorgona 3, St. George Coll. (Figured by Hastings 1930: fig. 120.)

(Holotype specimen NHM 1929.4.26.28. Galapagos Stn 9A, cited by Hastings (1930), cannot be located.)

Other material examined: NHM 1930.9.18.1., Puntas Arenas, Central America; NHM 1966.3.2.2., East of Angel de Guardia Id, Gulf of California, 40 fathoms; NHM 1966.9.2.6. (in part) (as *Antropora* sp.), Massawa Harbour, Red Sea coast of Ethiopia, N. A. Powell; NHM 1970.2.8.7., Teshie Rocks, E of Accra, 1–2m. Coll. W. Pople; NHM 1970.8.10.19., SE of Tema, Ghana. Coll. W. Pople; NHM 1975.9.10.7–9., South Seymour Id, Galapagos Islands; NHM 1992.1.23.17., Tamarin, Mauritius; NHM 1961.11.2.53. (as *Crassimarginatella leucocypha*), Campeche Bank, Gulf of Mexico, 24°4'N, 91°51'W, 26 fathoms. Coll. A. Cheetham.

Description

Colony encrusting, multilaminar. Autozooids distinct, irregularly oval, with thin mural rim. Gymnocyst vestigial; cryptocyst, narrow, granular, concave, thicker proximally, inner margin sometimes denticulate. Opesia almost filling entire frontal area. Interzooidal angles with either small rounded kenozooids or small interzooidal avicularia; mandible semi-circular to triangular with a rounded tip, no crossbar, but condyles are present. Endozooidal ovicells, forming rather shallow caps on autozooids, are described by Mawatari and Mawatari (1981). Colour, when alive or dried, ranging from white to light pink to pinkish-brown with increasing age and calcification.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Measurements (mm): mean±standard deviation

Specimen	n	Autozooid Length	Autozooid Width	Opesial Length	Opesial Width	Avic. Length
NHM 1929.4.26.72. Paratype.	30	0.37±0.07	0.28±0.03	0.28±0.03	0.17±0.02	–
Cook (1968a)	–	0.35–0.52	0.29–0.36	0.19–0.34	–	0.06–0.13
M and M (1981)	–	0.3–0.5	0.2–0.4	0.2–0.4	0.1–0.2	–

Remarks

The most characteristic features of this species are the presence of kenozooids, its often multilaminar nature and its pinkish coloration even when dried. Osburn (1950) noted that colonies may develop erect irregular branches (to 50mm high) particularly when in association with gastropods shells inhabited by pagurid crabs. The dry sectioned specimen (NHM 1966.3.2.2.) from the Gulf of California shows well the multilaminar form of *A. tincta*, as well as its pinkish coloration.

Marcus (1937) described *Crassimarginatella leucocypha* sp. nov. from Brazil, distinguishing it from *A. tincta* by the frequency of kenozooids, the size of the interzooidal avicularia and the shape of their mandibles. Hastings (1930) remarked that some colonies of *A. tincta* have no avicularia whilst in others they are very frequent, a feature noted in *Antropora leucocypha* by Winston (1982). The distinction between the two species has been maintained subsequently, although Cook (1968a) and Winston (1982) both noted the similarity between *A. leucocypha* and *A. tincta*, but there has been no recent redescription of Marcus' species and his type material has not been available for study. Winston's (1982) figures 36 and 37, appear to show two different species though she attributes them to smaller (younger ?) and larger colonies, respectively. Specimen NHM 1961.11.2.53. from the Gulf of Mexico, was originally attributed to *Crassimarginatella leucocypha*, but is undoubtedly *A. tincta*. (NHM 1986.8.14.9. as *Antropora leucocypha*, from Fort Pierce, Florida, is a specimen of *Antropora minor*.) *Crassimarginatella leucocypha* Marcus, 1937, may perhaps prove to be a junior synonym of *A. tincta* (or *A. minor*), but in the absence of accessible holotype material this question cannot be satisfactorily addressed. Rucker (1967) figured as *Antropora leucocypha* a species which looks like neither of the two London specimens mentioned above. Mawatari and Mawatari (1981) figured specimens attributed to *A. leucocypha* and *A. tincta* from Japan which appear to be indistinguishable both in shape and size, although they differentiated between the two species on the basis of the form, size and occurrence of avicularia. In their description of *A. leucocypha*, Mawatari and Mawatari (1981) noted vicarious avicularia as large as the autozooids; these were illustrated in their figure 3, but appear to be regenerated autozooids, showing two cryptocystal rims, rather than vicarious avicularia as described.

A. tincta has a morphology not unlike that of species of the genus *Akatopora* Davis, 1934, as discussed by Gordon (1986); future investigations of *Akatopora* species may remove *A. tincta* from the genus *Antropora* Norman.

Distribution

Galapagos Islands; Point Conception, California; Gulf of California; Peru; Mazatlan, Mexico; Jicaron Islands, Panama; Gorgona Islands, Colombia; Gulf of Mexico; Balboa, Brazil; Ghana, West Africa; Mauritius; Japan.

This species has been recorded from tropical and subtropical regions of the E. Pacific, W.

FIGURE 2. *Antropora minor* (Hincks, 1880b). **A**, Holotype specimen NHM 1899.5.1.654., Bahia, Brazil. Group of zooids, two ovicellate zooids to the left of frame. x108. **B**, NHM 1885.12.24.13., (Holotype specimen of *A. marginella* Hincks, 1884), Mergui Archipelago. Group of zooids (including ovicellate zooids) showing the coarsely granular cryptocyst and lack of gymnocyst. x54. **C**, NHM 1888.4.16.9., Fernando Noronha, Brazil. Group of autozooids showing the raised avicularia and kenozooidal papillae. x72. **D**, NHM 1887.12.9.327. (Type specimen of *A. papillatum* Busk, 1884), 'Challenger' Stn 208, the Philippines. Group of autozooids showing the granular cryptocyst, minimal gymnocyst and raised avicularia. x90. **E**, NHM 1931.12.30.17. (as *Membrendoecium ovatum* Canu & Bassler, 1929), off Sirun Island, Tawi-tawi Islands, Philippines. Group of autozooids showing kenozooidal papillae and evidence of regenerative growth. x72. **F**, NHM 1997.10.6.2., Suva Barrier Reef, Fiji. Group of autozooids showing the positioning of the small interzooidal avicularia, and shape and size of a large vicarious avicularium (centre). x63.

Atlantic, W. Africa and Japan but has not been reported from the SW Pacific.

The following species form a distinct group within the genus *Antropora* Norman, 1903b due to the presence of large vicarious avicularia as well as small interzooidal avicularia common to all members of the genus. The vicarious avicularia are extremely similar in form in all these species, however, their occurrence, and the regularity and form of the small interzooidal avicularia differ greatly.

Antropora minor (Hincks, 1880b)
(Fig. 2A–F)

Membranipora trifolium var. *minor* Hincks, 1880b: 87, pl. 11, fig. 6.

Membranipora trifolium var. *minor*: Hincks, 1885: 147, pl. 8, fig. 7; Robertson, 1921: 47; Waters, 1906: 14.

Dacryonella minor Canu and Bassler, 1929: 131, pl. 13, figs 9–12.

Membrendoecium minus Marcus, 1937: 50, pl. 9, fig. 22 A,B.

Antropora minus Cook, 1968a: 139, fig. 10; Mawatari and Mawatari, 1981: 34.

Amphiblestrum papillatum Busk, 1884: 66, pl. 3, fig. 1.

Membranipora papillata Waters, 1898: 668, 682.

Antropora papillatum Thornely, 1905: 110.

Membrendoecium ovatum Canu and Bassler, 1929: 95, pl. 6, figs 3–5.

Antropora ovata Cuffey and Cox, 1987: 86, fig. 2H.

Dacryonella ogivalina Canu and Bassler, 1929: 132, pl. 13, fig. 8.

Antropora ogivalina Scholz, 1991: 280, fig. 4.

Membrendoecium claustracrassum Canu and Bassler, 1930: 7, pl. 1, figs 3–7.

Antropora claustracrassa Osburn, 1950: 50, pl. 4, fig. 6.

Antropora claustracrassa: Cuffey and Cox, 1987: 86.

Membranipora marginella Hincks, 1884: 358, pl. 13, fig. 1; Hincks, 1893: 204; Waters, 1898: 658, 669.

not *Amphiblestrum marginella* Thornely, 1905: 110.

Antropora marginella Harmer, 1926 (in part): 234; Hastings, 1930: 714; Powell, 1967: 164, pl. 1, fig. 5.

Material examined

Holotype: NHM 1899.5.1.654., Bahia, Brazil. Hincks Coll.

Other material examined: NHM 1888.4.16.9., Fernando Noronha, Brazil; NHM 1931.12.30.41., Alb. Sta. 5151, off Sirun Island, Tawi-tawi Islands, Philippines. 24 fathoms. (exc. USNM); NHM 1992.1.23.17., Tamarin, Mauritius; NHM 1975.18.70. (as *Antropora* sp.), Tungku Beach, Dent Peninsula, NE Sabah; NHM 1975.18.71,72. (as *Antropora* sp.), East coast of Labuan Id, Sabah; NHM 1966.9.2.6. (in part) (as *Antropora* sp.), Massawa Harbour, Red Sea coast of Ethiopia, N. A. Powell; NHM 1887.12.9.327. (2 slides.) (Type of *Amphiblestrum papillatum*), 'Challenger' Stn 208, near the Philippines. 11°37'N., 123°31'E. 18 fathoms, blue mud; USNM 7935 (Type of *Dacryonella ogivalina*), Alb. Sta. 5147, off Sulade Id, Sulu Arch., Philippines. 21 fathoms; NHM 1931.12.30.42. (as *Dacryonella ogivalina*), Alb. Sta. D5217, Anima Sola Id, Ragay G., off N. Burias, Philippines. 13°20'N., 123°14'15"E. 105 fathoms. (exc. USNM); USNM 8472 (Cotype of *Membrendoecium claustracrassum*, 2 pieces), Alb. Sta. D2813. Galapagos Is 40 fathoms; NHM 1933.12.10.10. (as *Membrendoecium claustracrassum*), Alb. Sta. D2813. Galapagos Is 40 fathoms. (exc. USNM); USNM 7867 (Cotype of *Membrendoecium ovatum*, 2 pieces), Alb. Sta. 5137, Julo, Philippines. 20 fathoms; USNM 7868 (Cotype of *Membrendoecium ovatum*, 2 pieces), Alb. Sta. 5179, off Romblon Light, Romblon, Philippines. 37 fathoms; NHM 1931.12.30.16. (as *Membrendoecium ovatum*), Alb. Sta. 5179, off Romblon Light, Romblon, Philippines. 37 fathoms. (exc. USNM); NHM 1931.12.30.17. (as *Membrendoecium ovatum*), Alb. Sta. 5151, off Sirun Island, Tawi-tawi Islands, Philippines. 24 fathoms. (exc. USNM); NHM 1931.12.30.41. (as *Dacryonella minor*), Alb. Sta. 5151, off Sirun Island, Tawi-tawi Islands, Philippines. 24 fathoms. (exc. USNM); NHM 1885.12.29.13. (Syntype of *Antropora marginella*), Mergui Archipelago (off Thailand), Burma (Myanmar), India. Dr. Anderson Coll.; NHM 1899.5.1.602. (Syntype of *Antropora marginella*), Mergui Archipelago (off Thailand), Burma (Myanmar), India. Hincks Coll.; NHM 1997.10.6.2., Suva Barrier Reef, Fiji; NHM 1997.10.6.19., Suva Barrier Reef, Fiji. Reef Crest; NHM

1997.10.6.25., Tailevu Point, Viti Levu, Fiji; NHM 1997.10.6.26., Suva Barrier Reef, Fiji.

Description

Colony encrusting, multilaminar. Autozooids oval, bordered by a distinct, thin mural rim, separated by deep grooves, often wide. Gymnocyst generally minimal; cryptocyst coarsely granular, concave, deeper proximally than laterally, sloping basally. Opesia large, broadly oval or sub-triangular, narrowing distally, occupying over half of the frontal area. Single small interzooidal avicularia, elongate, rounded, mostly distally directed; mandible rounded or more acute, triangular, no crossbar; a cryptocystal rim around avicularium opesia; avicularium raised on small cystid (papillary eminences) seated in the angular interzooidal spaces. Small kenozooidal papillae are also often found at the proximal ends of autozooids in the interzooidal angles either in place of or in conjunction with the avicularia. Ovicells endozooidal, vestigial, indistinct, cap-like. The large autozooid-sized vicarious avicularia described above are often present, although they may be absent from large areas of some colonies; rostrum broadly triangular, its lateral walls raised.

Remarks

Antropora minor is characterised by the lack of a gymnocyst, the interzooidal avicularia on raised cystids, papillae-like kenozooids found proximally to the autozooids, and the presence of large vicarious avicularia. However, the frequency and spacing of both the kenozooids and the vicarious avicularia vary greatly between colonies.

The presence of small kenozooids in *A. minor* is unusual in *Antropora* and is seen otherwise only in *A. tincta*. These two species are multilaminar, and kenozooids may reflect discontinuities in colony form associated with multilayered growth. Canu and Bassler (1929) in their discussion of *Membrendoecium ovatum*, state that while autozooidal regeneration is common in *Antropora* (*Membrendoecium*) species, it is extraordinarily frequent in this species (e.g. NHM 1931.12.30.17.); the presence of kenozooids may perhaps indicate or facilitate regenerative growth.

The synonymy of *Membranipora trifolium* var. *minor* Hincks and *Amphiblestrum papillatum* Busk was first proposed by Waters (1898; 1909) but rejected by Marcus (1937). Cook (1968a) commented on the similarity of *A. minor* with *A papillatum*, but distinguished the two species on size, autozooids of *A. papillatum* being larger than those of *A. minor*.

Canu and Bassler (1929) remarked on the great resemblance of their new species, *Dacryonella ogivalina* to *Antropora minor* (Hincks, 1880b) but concluded that they were separate species due to the greater autozooidal dimensions of *D.*

Measurements (mm): mean±standard deviation

Specimen	n	Autozooid Length	Autozooid Width	Opesial Length	Opesial Width	Avic. Length
1899.5.1.654. Holotype.	30	0.32±0.03	0.24±0.02	0.19±0.01	0.14±0.01	0.08±0.01
C and B (1929) (*M. ovatum*)	–	0.50	0.35–0.40	0.30	0.22	–
C and B (1929) (*D. ogivalina*)	–	0.48–0.50	0.30	0.20–0.22	0.18–0.20	–
C and B (1929) (*D. minor*)	–	0.35–0.45	0.25–0.30	0.15–0.25	0.11–0.20	–
C and B (1930) (*M. claustracrassum*)	–	0.4–0.5	0.3	0.26–0.30	0.16–0.18	–
Cook (1968a) (*A. papillatum*)	–	0.30–0.42	0.15–0.23	0.12–0.15	–	0.05–0.09
Cook (1968a) (*A. minus*)	–	0.25–0.33	0.17–0.20	0.15–0.23	–	0.04–0.07
NHM 1899.5.1.602. (*A. marginella*)	30	0.32±0.04	0.22±0.02	0.19±0.03	0.13±0.02	0.09±0.01
NHM 1997.10.6.2.	20	0.35±0.04	0.28±0.03	0.19±0.03	0.15±0.02	0.08±0.01

ogivalina. A variation in autozooidal size in *D. ogivalina* was observed by Canu and Bassler (1929) leading them to present two sets of measurements, for small and large autozooids, from a single colony.

A comparison of specimens of *A. papillatum* from the Philippines, *D. ogivalina* from the Philippines, *M. ovatum* and *A. minor* from Brazil shows that despite the smaller average size of the autozooids of *A. minor* and the Philippine colonies of *A. papillatum* and *D. ogivalina* they are otherwise morphologically indistinguishable.

Canu and Bassler (1920) cite *Amphiblestrum papillatum* Busk, 1884 as the 'genotype' species of the genus *Membrendoecium* Canu and Bassler, 1917. With the synonymy of *A. minor* and *A. papillatum*, *Membrendoecium* Canu and Bassler, 1917 becomes a junior subjective synonym of *Antropora* Norman, 1903b.

Canu and Bassler (1930) noted that their *Membrendoecium claustracrassum* sp. nov. from the Galapagos Islands, could perhaps be the same species as *A. papillatum,* and comparison of cotype (USNM 8472) and topotype (NHM 1933.12.10.10.) material of *M. claustracrassum* with the specimens listed above, shows this indeed to be the case. The cotype material of *M. claustracrassum* also possesses several autozooid-sized vicarious avicularia which have not been noted previously.

Osburn (1950) noted that the ancestrula of *A. claustracrassa* was half the size of later zooids while autozooids originating secondary laminae were noticeably larger than other zooids; he also noted that occasionally the avicularia are replaced by small 'nodules' (kenozooids).

The presence of vicarious avicularia in *M. claustracrassum* suggests the synonymy of *A. minor* and *A. marginella*. Although neither the type specimen of *A. minor* (NHM 1899.5.1.654.) nor that of *A. marginella* (NHM 1899.5.1.602.) show vicarious avicularia, in all other respects the two specimens are identical and indistinguishable from *M. claustracrassum* which does possess vicarious avicularia.

Hincks (1884) did, however, describe vicarious avicularia in *Membranipora marginella* sp. nov., noting 'cells with a very large oral operculum of a dark horn-colour', concluding that they were either avicularia or a reproductive structure. Hincks (1893) later realised that they were in fact vicarious avicularia as noted by Waters (1898).

Thornely (1905) also noted the presence of vicarious avicularia, in her description of *Amphiblestrum marginella* from Ceylon; she described the small interzooidal avicularia as more pointed than described by Hincks and 'directed upwards instead of downwards'; examination of her material (NHM 1936.12.30.6.) shows that she was describing a colony of the new species, *Antropora erectirostra*, which also has vicarious avicularia.

Harmer (1926) in his description of *A. marginella* was unsure about the presence of 'rosette-plates' (septula) but doubted that 'pore-chambers' (dietellae) were present. It is unsure to which specimens Harmer (1926) referred in his descriptions as material he examined has now been assigned to not only *A. minor*, but also *Parantropora laguncula* and *Retevirgula aggregata*.

A specimen from Fort Pierce, Florida (NHM 1986.8.14.9.), originally labelled *Antropora leucocypha* (Marcus, 1937), is undoubtedly *A. minor*. The taxonomic identity of Marcus' species, and any synonymy, is difficult without reference to the type material, in the absence of which no conclusion may be drawn.

Osburn (1927) in his original description of the multilaminar *Membrendoecium compressum* noted its similarity to *A. papillatum*, though it differed in its closely packed zooids and thicker colony. Marcus (1937) considered that *M. compressum* might be a synonym of *A. minor*. Osburn's type material has not been available for study.

The species described by Canu and Bassler (1929) as *Amphiblestrum papillatum* Busk (NHM 1931.12.30.25.), mentioned by Cook (1968a), differs from Busk's species in a number of ways: it has six to eight spines around the distal end of each autozooid, the opesial rim is greatly raised, it bears no avicularia, the gymnocyst is elongated, and finally it bears large globular hyperstomial ovicells. These features put this specimen within one of the genera akin to the genus *Crassimarginatella* Canu, 1900, rather than genus *Antropora* Norman.

Distribution

Bahia, and Fernando Noronha, Brazil; Guyamas, Mexico; La Libertad, Ecuador; Colombia; Panama Canal; Galapagos Islands; Tahiti; Enewetak Atoll; Chatham Islands; Fiji; Japan; Philippines; Singapore; Mergui Archipelago (off Thailand); Ceylon (Sri Lanka); Red Sea.

This species appears to have a circum-tropical distribution.

Antropora typica (Canu and Bassler, 1928a) (Fig. 1F; Fig. 3A)

Antropora granulifera Harmer, 1926: 232 (in part), pl. 14, figs 12–14.

Antropora granulifera: Mawatari and Mawatari, 1981: 28 (in part), fig. 2.

Dacryonella typica Canu and Bassler, 1928a: 87, pl. 5, figs 4–8; pl. 32, figs 11,12.

Dacryonella typica: Canu and Bassler, 1928b: 8, 65, pl. 1, fig. 10.

Antropora typica Rucker, 1967: 817, fig. 12b.

Antropora typica: Winston, 1986: 5, figs 1,2.

Membrendoecium strictorostris Canu and Bassler, 1928a: 23, pl. 2, fig. 7.

Canua (*Membrendoecium*) *strictorostris* Osburn, 1940: 358.

Crassimarginatella cookae Hayward, 1988: 277, figs 2c–e.

Material examined

Holotype Series: USNM 7484 (2 pieces), Alb. Sta. 2319, North of Cuba. 23°10'37"N, 82°20'6"W, 143 fathoms; USNM 7485 (2 pieces), Alb. Sta. 2320, North of Cuba.

Other material examined: NHM 1932.3.7.51., North of Cuba. (exc. USNM); NHM 1899.7.1.988,989. (as *Antropora sp.*), John Adam's Bank, Brazil; NHM 1928.3.6.49. (as *Antropora granulifera*), Siboga Stn 310. E. Sumbawa, Malaysia; NHM 1928.9.13.16. (as *Antropora granulifera*), Okinose off Tokyo, Japan; NHM 1928.9.13.17. (as *Antropora granulifera*), Shikoku, Japan; USNM 7552 (Holotype of *Membrendoecium strictorostris*), Alb. Sta. 2319, North of Cuba. 23°10'37"N, 82°20'6"W, 143 fathoms; NHM 1934.10.8.9., Mauritius.

Description

Colony unilaminar, encrusting. Autozooids distinct, oval, separated by indistinct grooves, may form longitudinal rows. Thin mural rim. Opesia two-thirds of total autozooid length, oval, with a narrow border of granular cryptocyst, broadest proximally, where it grades into smooth obvious gymnocystal calcification. A pair of small, distally directed, interzooidal avicularia at the distal end of most autozooids; mandible acutely triangular; rostrum narrow, acute, tear drop-shaped, distally directed, with a distinct granular cryptocyst proximally and elongate oval opesia; lacking a crossbar. Ovicell endozooidal, small, partly immersed beneath succeeding autozooid, but distinct in frontal view; hemispherical, imperforate, smooth, cap-like. Operculum of ovicellate zooids wider than autozooids, and closing the ovicell. Large vicarious avicularia occur sporadically, each with a semi-elliptical mandible equivalent to one-third total length, supported by a slightly raised, arched rostrum. One or, generally, two very thin areas of basal calcification, distally (see *A. granulifera* above). Canu and Bassler (1928a) describe living colonies as light rose in colour.

Remarks

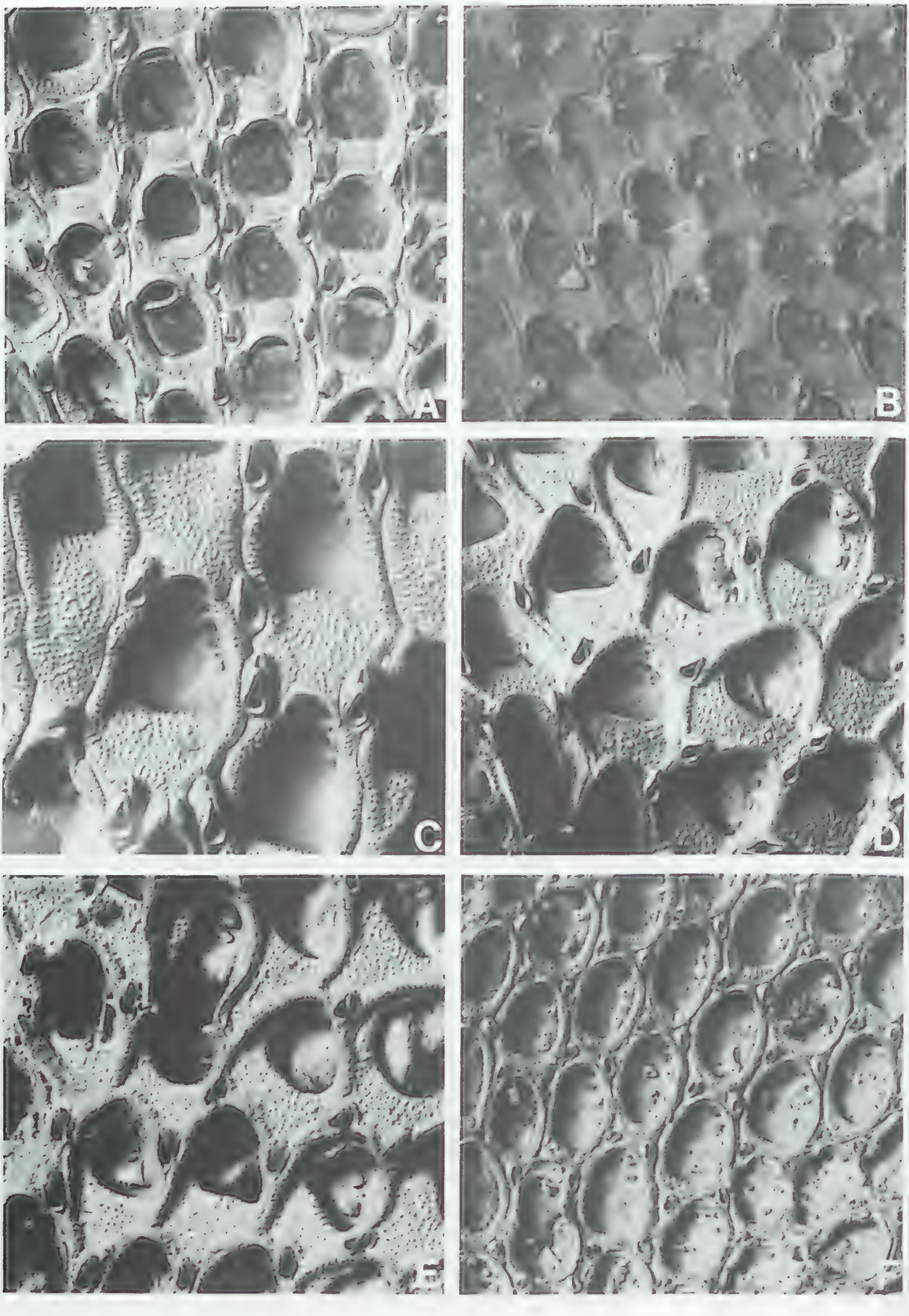
This species is characterised by the presence of frequent tear drop-shaped interzooidal avicularia, with acute distally pointing mandibles; the gymnocyst is obvious and the large vicarious avicularia are also often quite frequent.

The size of the autozooids varies greatly within colonies and between geographic localities, as noted by Canu and Bassler (1928a) in material from off Cuba, and has thus been mistakenly identified subsequently by several authors.

Harmer (1926) described material of *Antropora granulifera* from Malaysia (NHM 1928.3.6.49.) and Japan (NHM 1928.9.13.16, 17.) which are clearly referable to this species. Following Cook (1968a), Hayward (1988) recognised another Natural History Museum specimen (NHM 1934.10.8.9.), from Mauritius, assigned to *A.*

Measurements (mm): mean±standard deviation

Specimen	n	Autozooid Length	Autozooid Width	Opesial Length	Opesial Width	Avic. Length
USNM 7484 Holotype.	30	0.46±0.06	0.29±0.05	0.26±0.02	0.18±0.03	0.12±0.01
C and B (1928a)	–	0.45	0.30	0.20	0.15	0.10
C and B (1928b)	–	0.40–0.45	0.25–0.30	0.20–0.23	0.17–0.20	–
Hayward (1988) (*C. cookae*)	20	0.51±0.06	0.31±0.04	–	–	–


A
B
C
D

granulifera, as a different species, describing it as the new species, *Crassimarginatella cookae*. Comparison of the specimens cited by Harmer (1926) and Hayward (1988) with Canu and Bassler's (1928a) type series of *Dacryonella typica* (USNM 7484, 7485) shows them to be conspecific.

Canu and Bassler (1928a) described *Membrendoecium strictorostris* from Alb. Stn 2319, north of Cuba, the type locality of *Dacryonella typica*; comparison of the two sets of type material shows them to be the same species, though neither types show the vicarious avicularia seen in other material belonging to this species.

Canu and Bassler (1927) described *Dacryonella levigata* sp. nov. from Hawaii; the general description and appearance seem very similar to *C. typica*, although their measurements of *D. levigata* are smaller than those of the specimens listed above. In the absence of material of *D. levigata*, no firm conclusion as to its relation with *C. typica* can be voiced. Rucker's (1967) figured specimen is clearly recognisable as this species, as are those specimens figured by Winston (1986).

The fossil type series specimens from the Pliocene of Panama (USNM 70838), are not included in the above review as they differ from the Recent material in several respects, i.e. a more extensive cryptocyst, less frequent occurrence of the small interzooidal avicularia and absence of large vicarious avicularia, and cannot be synonymised with confidence.

Distribution

Cuba; Jamaica; John Adam's Bank off Brazil; Mauritius; Sumbawa, Malaysia; Japan.

Antropora erectirostra Tilbrook, new species (Fig. 3B,C)

Amphiblestrum marginella Thornely, 1905: 110.

Material examined

Holotype: NHM 1899.7.1.1086., Ceylon (Sri Lanka). Busk Coll.

Paratypes: NHM 1899.7.1.1084, 1085, 1087., Ceylon (Sri Lanka). Busk Coll.

Other material examined: NHM 1936.12.30.6. (as *Antropora marginella*), Gulf of Manaar, Ceylon. L. R. Thornely.

Etymology

erectus, L. upright; *rostrum*, L. beak. Named after its highly raised small interzooidal avicularia.

Description

Colony, encrusting, unilaminar. Autozooids about twice as long as wide, separated by deep grooves. Gymnocyst is minimal; cryptocyst granular, very deep proximally, sloping slightly basally, distal edge flat to somewhat convex. Opesia rounded, triangular, occupying half frontal area. On many autozooids one or two interzooidal avicularia are placed disto-laterally; mandible

Measurements (mm): mean±standard deviation

Specimen	n	Autozooid Length	Autozooid Width	Opesial Length	Opesial Width	Avic. Length
NHM 1899.7.1.1086. Holotype.	25	0.50±0.04	0.24±0.03	0.25±0.03	0.16±0.09	0.13±0.02

FIGURE 3. **A**, *Antropora typica* (Canu & Bassler, 1928a), NHM 1928.3.6.49., E Sumbawa, Malaysia. Group of zooids, showing several ovicellate zooids (note the wider opercula) and a large vicarious avicularium slightly left of centre. x36. **B**, *Antropora erectirostra* new species, Holotype specimen NHM 1988.7.1.1086., Ceylon (Sri Lanka). Group of autozooids showing the zooidal arrangement and highly raised interzooidal avicularia. x36. **C**, *Antropora erectirostra* new species, Paratype specimen NHM 1988.7.1.1085., Ceylon (Sri Lanka). Group of autozooids showing the granular cryptocyst and minimal gymnocyst; several of the interzooidal avicularia appear to have regenerated. x90. **D**, *Parantropora penelope*, new genus, new species, Holotype specimen NHM 1997.10.6.1., Magnetic Island, Townsville, Queensland, Australia. Group of autozooids. x45. **E**, *Parantropora penelope*, new genus, new species, Holotype specimen NHM 1997.10.6.1., Magnetic Island, Townsville, Queensland, Australia. Group of zooids including a very large vicarious avicularium at the centre top. x54. **F**, *Parantropora laguncula* (Canu & Bassler, 1929), NHM 1931.12.30.14., off Sirun Island, Tawi-tawi Islands, Philippines. Group of zooids including a very large vicarious avicularium. x36.

acutely triangular, arched, distally directed; rostrum distally pointed, raised. Rare vicarious avicularia, as large as autozooids; rostrum broadly triangular, narrowing distally, its lateral walls raised. Ovicells small, endozooidal. Kenozooids frequent in disturbed areas of a colony.

Remarks

The presence of the raised, distally directed interzooidal avicularia make this species easily distinguishable from others of the genus.

The autozooids form approximately parallel rows, becoming rather longer and slimmer with increasing colony size. The interzooidal avicularia are most acute and the rostrum most raised nearer the growing edge, the mandibles are more arched.

Thornely's specimen from Ceylon (NHM 1936.12.30.6. as *A. marginella*) is undoubtedly *A. erectirostra* (see *A. marginella* discussion above).

Silén's (1941) *Antropora erecta* sp. nov. is very similar to *Antropora erectirostra*, though he describes the colony as erect and branching, with the 'structure of a cylinder surrounding a cavity'; he makes no mention of the large vicarious avicularia, seen only rarely in *A. erectirostra*.

Distribution

This species is known only from Sri Lanka (Ceylon).

Parantropora Tilbrook, gen. nov.

Generic diagnosis

Colony encrusting. Autozooidal cryptocyst moderately developed around the opesia, gymnocyst negligible or absent. Spines absent. Small interzooidal avicularia present. Large spatulate vicarious avicularia present, much larger than autozooids. Ovicells endozooidal. Mural septula present.

Type species

Parantropora penelope Tilbrook, new species.

Etymology

The genus is named for its resemblance to *Antropora*.

Remarks

This genus is very similar to *Antropora*. However, the lack of dietellae, the presence of lateral-wall (mural) septula and the occurrence of very large spatulate vicarious avicularia, make species of this genus quite distinct. The presence of 'special zooecia' was first noted by Canu and Bassler (1929) in *Membrendoecium lagunculum* sp. nov., though they failed to recognise them as avicularia. Whereas, the vicarious avicularia in species of *Antropora* are autozooid size and shape and so easily overlooked in a colony (Figs 2F and 3A), those of *Parantropora* are considerably larger than the surrounding autozooids; in *P. penelope* (Fig. 3E) they are one-third as long again, and in *P. laguncula* (Fig. 4A) almost half as long again, as the average autozooid.

Species of *Parantropora* generally have a more delicate structure to their side walls than do species of *Antropora*.

Parantropora penelope Tilbrook, new species (Fig. 3D,E)

?*Antropora granulifera* Ryland and Hayward, 1992: 229, fig. 2c.

Etymology

Named after my mother, Leah Penelope Tilbrook.

Material examined

Holotype: NHM 1997.10.6.1., Magnetic Island, Townsville, Queensland. Coll. J. S. Ryland.

Other material examined: NHM 1997.10.6.17., Erakor Id, Vanuatu; NHM 1997.10.6.18., Erakor Id, Vanuatu. Reef Flat; NHM 1997.10.6.15., Carter Reef, Great Barrier Reef, Australia; NHM 1997.10.6.16., Suva Barrier Reef, Fiji. Reef Flat; NHM 1997.10.6.23., Suva Barrier Reef, Fiji.

Description

Colony encrusting, unilaminar. Autozooids irregularly oval to hexagonal, separated by shallow grooves. Gymnocyst minimal; cryptocyst occupying slightly less than half total autozooid length, flat or slightly concave, coarsely beaded. Opesia subtriangular. At the distal end of each autozooid a pair (rarely one) of small, tear drop-shaped interzooidal avicularia. Rostrum acute to frontal plane, directed distally or disto-medially, with an acutely triangular mandible articulated on condyles. Large vicarious avicularia also present, generally larger than autozooids; rostrum raised distally, cryptocyst, narrow, coarsely granular, laterally constricted; opesia rounded; mandible spatulate, articulated on pointed, triangular condyles, angled slightly proximally, situated proximal to lateral rostral constriction. Ovicells endozooidal, small, granular, cap-like, derived from distal zooid. Ovicell not closed by

Measurements (mm): mean±standard deviation

Specimen	n	Autozooid Length	Autozooid Width	Opesial Length	Opesial Width	Avic. Length
NHM 1997.10.6.1. Holotype.	20	0.45±0.06	0.28±0.04	0.20±0.03	0.18±0.03	0.09±0.02

Specimen	n	Vic. Avic. Length	Vic. Avic. Width
NHM 1997.10.6.1. Holotype.	6	0.6 ± 0.06	0.27 ± 0.02

operculum. Mural septula present in the thin lateral walls, which may be strengthened by basolateral buttresses.

Remarks

Parantropora penelope looks superficially very similar to *A. typica*. However, it differs in its lack of a gymnocyst, its smaller opesia and in having large spatulate vicarious avicularia. *P. penelope* is distinguishable from *P. laguncula* by its smaller, more triangular opesia and more acutely pointed interzooidal avicularia.

The specimen figured by Ryland and Hayward (1992) as *Antropora granulifera* is certainly not Hincks's species; it is possible that *P. penelope* is the species figured, although its identity must remain uncertain until their material can be re-examined.

Distribution

Great Barrier Reef, Australia; Erakor Islands, Vanuatu; Suva Barrier Reef, Fiji.

This species appears to be limited to the tropical south west Pacific.

Parantropora laguncula (Canu and Bassler, 1929)
(Fig. 3F; 4A,B)

?*Biflustra savartii* Audouin, *var.* MacGillivray, 1891: 79, pl. 9, fig. 6.

?*Membranipora savarti*: MacGillivray, 1895: 38, pl. 5, figs 6,7.

Antropora marginella Harmer, 1926 (in part): 234, pl. 14, fig. 15.

Membrendoecium savarti Canu and Bassler, 1929: 94, pl. 6, figs 1–3.

Membrendoecium lagunculum Canu and Bassler, 1929: 96, pl. 6, figs 6–11.

Antropora lagunculum Mawatari and Mawatari, 1981: 33.

Material examined

Holotype Series: USNM 7869 (5 pieces), Alb. Sta. 5478, off Tacbuc Point, E Leyte, Philippines. 57 fathoms.

Other material examined: NHM 1997.10.6.5–7., Tideway Reef, Great Barrier Reef. 10m; NHM 1997.10.6.24., ?Mourilyan Harbour, Coll. Bob Pearson; NHM 1931.12.30.19. (as *Membrendoecium lagunculum*), Alb. Sta. 5478, off Tacbuc Str., E Leyte, Philippines. 57 fathoms. (exc. USNM); NHM 1931.12.30.14. (as *Membrendoecium savarti*), Alb. Sta. 5151, off Sirun Id, Tawi-tawi Is, Philippines. 24 fathoms. (exc. USNM); NHM 1931.12.30.15. (as *Membrendoecium savarti* var. *minor*), Alb. Sta. 5151, off Sirun Id, Tawi-tawi Is, Philippines. 24 fathoms. (exc. USNM); NHM 1928.9.13.19. (as *Antropora marginella*), Torres Straits, Australia; NHM 1928.3.6.50. (as *Antropora marginella*), Siboga Station 81. Borneo Bank, Strait of Makassar, Malaysia. 0–34m; NHM 1928.3.6.51. (as *Antropora marginella*), Siboga Station 164. W. of N. end of New Guinea. 32m.

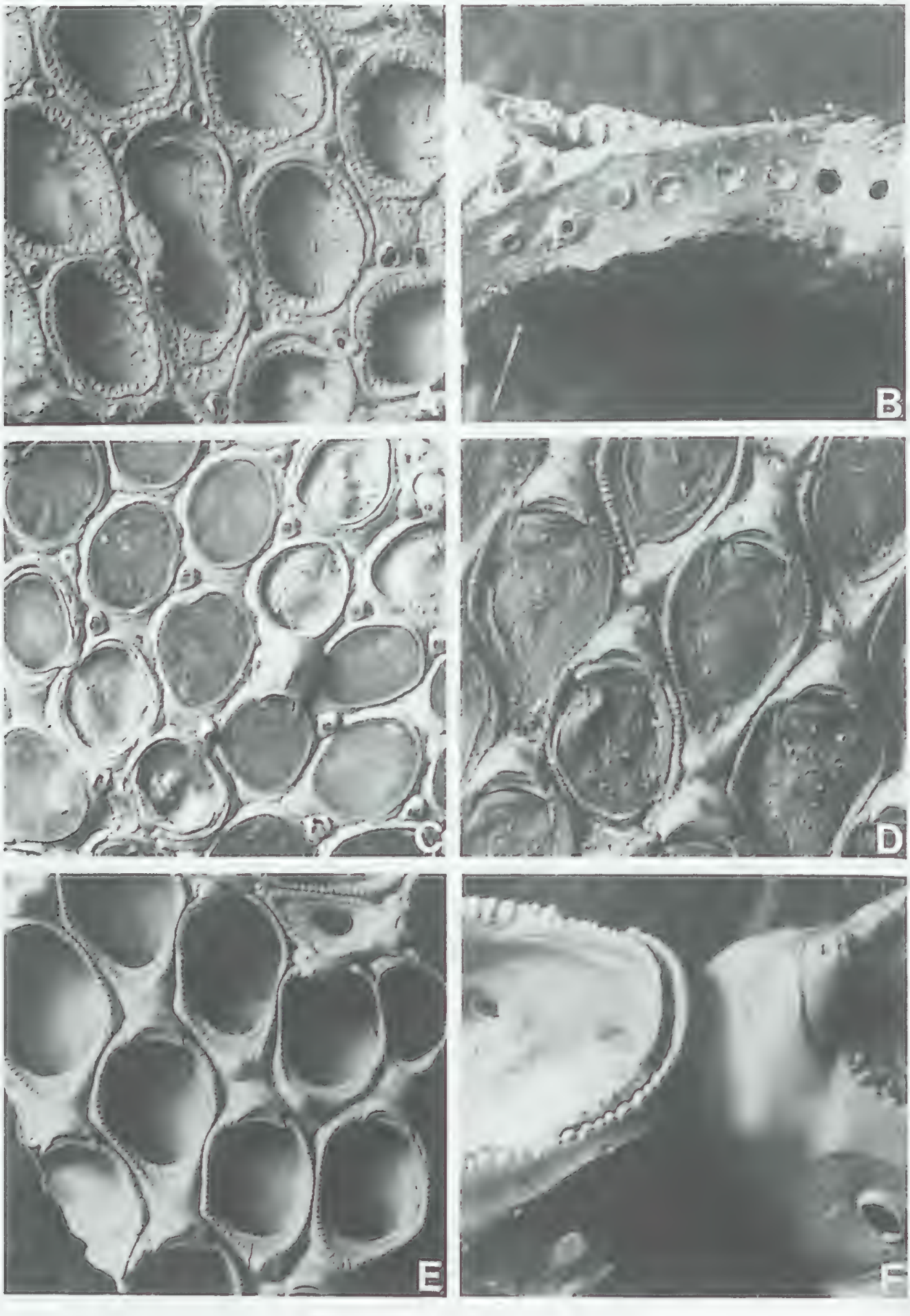
Description

Colony encrusting, unilaminar. Autozooids distinct, elongated or elliptical, separated by deep grooves. Gymnocyst reduced, surrounding zooids; cryptocyst coarsely granular, broadest proximally. Opesia elliptical or oval, occupying almost entire frontal area. Small, symmetrical, interzooidal avicularia are present at the interzooidal angles. Rostrum raised; mandible rounded-triangular, opesia with lateral constriction. Large vicarious avicularia frequent. Ovicells endozooidal, very small, smooth, raised cap-like.

Remarks

Parantropora laguncula is distinguished by its large oval opesia surrounded by a reduced gymnocyst.

According to Canu and Bassler (1929), MacGillivray (1891) recorded this species from


B
C
D
E
F

Measurements (mm): mean±standard deviation

Specimen	n	Autozooid Length	Autozooid Width	Opesial Length	Opesial Width	Avic. Length
C and B (1929) (*M. savarti*)	–	0.40–0.42	0.30	0.24–0.29	0.16–0.20	–
NHM 1997.10.6.5.	25	0.39±0.08	0.33±0.04	–	–	0.07±0.01
Specimen	n	Vic. Avic. Length	Vic. Avic. Width			
NHM 1997.10.6.5.	8	0.62±0.08	0.32±0.06			

the Tertiary of Victoria and the Recent of Western Australia, attributing it to *Biflustra savartii* Audouin. However, the figure accompanying MacGillivray's (1891) description bears little resemblance to *Parantropora laguncula*, here described. Canu and Bassler (1929) reported *Membrendoecium savarti* from the Philippines, attributing the specific name to MacGillivray whilst changing the generic attribution. In the same paper (Canu and Bassler 1929) they describe a new species, *Membrendoecium lagunculum*, which, following comparison of material of both species deposited in the Natural History Museum, London, proves to be identical to *B. savarti sensu* MacGillivray *non* Audouin. The combination *Parantropora laguncula* (Canu and Bassler, 1929) is consequently the correct name for this species.

Canu and Bassler (1929) noted that autozooid size in *Membrendoecium lagunculum* was variable and considered it to be dependent on substratum type, with autozooids at the margins generally largest, although they do not provide any measurements for this species. They did not describe large vicarious avicularia, seen in the type series of *Membrendoecium lagunculum*, despite their depiction in three of the figures (Canu and Bassler 1929: pl. 6, figs 6, 8 and 11); instead these were described as large aberrant zooids, with 'deformed' opesia, at the start of new autozooid series; the mandibular articulatory condyles can be clearly seen in their fig.11.

Silén (1941) considered that *Membrendoecium lagunculum* and *Antropora marginella* might prove to be a single species, by reference to Canu and Bassler's (1929) plate 6, figs 6–11 and Harmer's (1926) plate 14, fig. 15. Re-examination of Harmer's material of *Antropora marginella* shows that three specimens could be attributed to *P. laguncula*, namely NHM 1928.9.13.19. Torres Straits, Australia, NHM 1928.3.6.50. from Malaysia and NHM 1928.3.6.51. from New Guinea.

Distribution

Leyte and Tawi-tawi Is, Philippines; Torres Straits, Australia; Strait of Makassar, Malay; New Guinea; Great Barrier Reef.

This species is known from the Indo-Malaysian region and Western Australia and perhaps occurs more widely in the Southwest Pacific.

Genus ***Retevirgula*** Brown

Retevirgula Brown, 1948: 109.

Generic diagnosis

Colony thinly encrusting. Zooids united by

FIGURE 4. **A**, *Parantropora laguncula* (Canu & Bassler, 1929), NHM 1997.10.6.5., Tideway Reef, Great Barrier Reef, Australia. Group of zooids with thin cryptocystal rim and reduced gymnocyst (large vicarious avicularium visible in the centre). x45. **B**, *Parantropora laguncula* (Canu & Bassler, 1929), NHM 1997.10.6.7., Tideway Reef, Great Barrier Reef, Australia. Lateral wall showing septula. x144. **C**, *Retevirgula aggregata* Gordon, 1984, NHM 1928.9.13.18., Torres Straits, Australia. Group of zooids showing the deep separating grooves, small raised interzooidal avicularia and large globular keeled ovicell. x45. **D**, *Crassimarginatella papulifera* (MacGillivray, 1892), NHM 1881.10.21.355–9., Torres Straits, Australia. Group of zooids including ovicellate zooids, in which the operculum does not close the unifenestrate ovicell. x63. **E**, *Crassimarginatella papulifera* (MacGillivray, 1892), NHM 1881.10.21.355–9., Torres Straits, Australia. Group of zooids; note the presence of kenozooids. x45. **F**, *Crassimarginatella papulifera* (MacGillivray, 1892), NHM 1881.10.21.355–9., Torres Straits, Australia. Lateral view of two autozooids showing the mural pores and proximal papillae. x162.

short connecting tubes absent in some species. Opesia extensive, gymnocyst and cryptocyst reduced. Interzooidal avicularia common, sometimes replaced by kenozooids. Ovicells recumbent, smooth-walled or with a fenestra, often surmounted by an avicularium. Basal pore-chambers wanting. (Gordon 1984).

Type species

Membranipora acuta Hincks, 1885: 249, pl. 7, fig. 6.

Retevirgula aggregata Gordon, 1984
(Fig. 4C)

Antropora marginella Harmer, 1926 (in part): 234, pl. 14, fig. 15.

Retevirgula aggregata Gordon, 1984: 27, pl. 2, fig. D.

Retevirgula aggregata: Gordon, 1986: 30.

Material examined

NHM 1928.9.13.18. (as *Antropora marginella*), Torres Straits, Australia.

Description

Colony encrusting, unilaminar. Autozooids oval or rounded, distinct, separated by deep grooves. Gymnocyst minimal; cryptocyst granular, forming a very narrow rim; opesia rounded, occupying almost entire frontal area. Small interzooidal avicularia often found in the interzooidal angles; rostrum raised, rounded; mandible semicircular, distally directed. Kenozooids also present. Ovicells hyperstomial, smooth, globular, with a median suture, no fenestra.

Measurements (mm): mean±standard deviation

Specimen	n	Autozooid Length	Autozooid Width
Gordon (1984).	–	0.45–0.55	0.27–0.33
NHM 1928.9.13.18.	30	0.41±0.04	0.30±0.04

Remarks

In his account of *Antropora marginella*, Harmer (1926) described prominent, hyperstomial ovicells, with distinct median keels, in some specimens, referring in particular to specimen NHM 1928.9.13.18 from the Torres Straits. Such ovicells are not a feature of *Antropora* and re-examination of the specimen shows it to be attributable to the recently described *Retevirgula aggregata* Gordon, 1984.

Gordon (1984) distinguished his new species from other species of *Retevirgula* Brown, 1948, by the absence of connecting tubes and avicularian pivot bars (*R. aggregata* possesses condyles instead), both included in Brown's (1948) original generic diagnosis.

Distribution

Described by Gordon (1984) from Kermadec Ridge (type locality Curtis Is) and off Kahurangi Point, north-west South Island, New Zealand; this new record from Torres Straits, NE Australia suggests a considerable geographical range in the SW Pacific.

Genus ***Crassimarginatella*** Canu

Crassimarginatella Canu, 1900: 369.

Oochilina Norman, 1903a: 595.

Generic diagnosis

Colony encrusting, or erect from an encrusting base. Gymnocyst variable in extent, usually reduced. Opesia extensive, occupying the larger part of the frontal area; cryptocyst reduced, moderate or very narrow. Avicularia vicarious, lacking spines, with or without a pivot bar. Ovicells prominent, unifenestrate, or small and cap-like. Mural or basal pore-chambers present (cf. Harmelin 1973). (Gordon 1984).

Type species

Membranipora crassimarginata Hincks, 1880a: 71, pl. 9, fig. 1–1a.

Crassimarginatella papulifera (MacGillivray, 1882)
(Fig. 4D–F)

Membranipora papulifera MacGillivray, 1882: 116, fig. 9.

Membranipora papulifera: Waters, 1898: 658, 659, 660, 669.

Crassimarginatella papulifera Brown, 1952: 56, fig. 13.

Crassimarginatella (*Crassimarginatella*) *papulifera* Gordon, 1986: pl. 4F.

Material examined

NHM 1881.10.21.355–9., (as *Membranipora* sp.), Torres Straits, Australia, HMS Alert.

Description

Colony encrusting, unilaminar. Autozooids distinct, elongate, separated by deep grooves. Frontal membrane bordered by a thin crenellated mural rim. Gymnocyst minimal, sometimes papillate proximally; cryptocyst finely beaded, minimal, broader proximally than laterally, sloping basally. Opesia oval, very large, equivalent to 80–90% of frontal area. Ovicells, smooth, cap-like, slightly pointed, hyperstomial, unifenestrate, with at least some material being derived from the gymnocyst of distal autozooid. Operculum broad, does not cover ovicell orifice. Interzooidal communication by mural dietellae. No spines.

Measurements (mm): mean±standard deviation

Specimen	n	Autozooid Length	Autozooid Width
Brown (1952)	–	0.51–0.55	0.33–0.38
NHM 1881.10.21.355–9.	30	0.60±0.05	0.33±0.03

Remarks

The most striking feature of this species is the form of the ovicell, from which the specimen described above was identified using the plate published by Gordon (1986) of paralectotype material.

Norman (1903a) referred *Membranipora papulifera* MacGillivray, 1882, to his new genus *Oochilina*. However, this genus shared the same 'genotype' species, *Membranipora crassimarginata* Hincks, 1880a, with *Crassimarginatella* Canu, 1900, which therefore takes precedence.

Gordon (1986), in his discussion of *Crassimarginatella* (*Crassimarginatella*) *fossa* Uttley, 1951, assigned *Crassimarginatella papulifera* (MacGillivray, 1882) to the subgenus *Crassimarginatella* but now (Gordon, pers. comm.) regards each of the subgenera of *Crassimarginatella* as deserving generic status. This species is thus correctly *Crassimarginatella papulifera* (MacGillivray, 1882). Waters (1898), Brown (1952) and Gordon (1986) all record the presence of vicarious avicularia, but these have not been seen in the specimen described above, although there appears to be evidence of autozooidal regrowth, i.e. multiple occupancy of a single autozooidal skeleton.

Distribution

Port Phillip Heads, Victoria; Torres Straits, Australia; New Zealand (fossil).

Discussion

Several other species that have formerly been assigned to *Antropora* Norman, 1903b have also been examined and found to have been wrongly attributed. Harmer (1926) attributed *Membranipora nigrans* Hincks, 1882 to *Antropora*, but examination of material of this boreal species (Holotype: NHM 1886.3.6.9., Queen Charlotte Id, Canada; NHM 1911.10.1.610,611., Spitzbergen?; NHM 1919.6.25.40., Spitzbergen?; NHM 1938.11.30.25., off Del Monte, California; NHM 1955.10.3.63., Greenland), shows that Canu and Bassler (1929) and Cook (1968a) were correct in expressing doubts about the congeneric status of *Membranipora nigrans* and *A. granulifera* (see further discussion in Prenant and Bobin 1966).

Membrendoecium japonicum Canu and Bassler, 1929, automatically placed in *Antropora* by the synonymy of *Membrendoecium* Canu and Bassler and *Antropora* by Silén (1941), is not a species of *Antropora*. Examination of original material (NHM 1931.12.30.18., Cape Tsiuka, Japan) shows the regular form of kenozooids in the autozooidal framework, a feature more similar to species of *Menipea* Lamouroux, 1812 (a genus of erect species) than to *Antropora sensu stricto* (which are all encrusting, although see Silén's (1941) description of *A. erecta*) but this is not its true generic assignment either.

Gordon (1986) amended Norman's (1903b) generic diagnosis of *Antropora* when describing his new species *Antropora pacifera*. This species was also examined (Paratype: NHM 1985.1.22.2., NZOI Stn B488.); it completely lacks avicularia, and the ovicells are not endozooidal, but larger, separate structures, that have an obvious ectooecial rim around the granular endooecium, a distinct feature of the genus *Alderina* Norman, 1903a (Gordon, 1984).

It may transpire that several of the unexamined species listed above (see generic introduction) will be synonymised with one or more of the species described herein but until original material has been located the validity of these species cannot be tested.

The genus *Antropora* is presently placed within the Family Calloporidae Norman, 1903a; however, as Ryland and Hayward (1977) conclude 'this is a somewhat heterogeneous group'. The genera assigned to the family Calloporidae would thus benefit from a full systematic investigation. The familial diagnosis of Calloporidae emphasises the presence of prominent hyperstomial ovicells.

The genera *Antropora* and *Parantropora* gen. nov., have small endozooidal ovicells which would suggest that they belong to a family other than the Calloporidae.

Soule, Soule and Chaney (1995) discuss the Calloporidae, concluding that the Hincksinidae Canu and Bassler, 1927, should be reinstated for membraniporines with endozooidal ovicells and Alderinidae Canu and Bassler, 1927, for those with hyperstomial ovicells. However, the type genus of Hincksinidae, *Hincksina* Norman, 1903a is generally assigned to the Flustridae Fleming, 1828 (Ryland and Hayward 1977), and this proposal is thus unacceptable.

Vigneaux (1949) introduced the Antroporidae for *Antropora* Norman, 1903b, *Ogivalina* Canu and Bassler, 1917, *Ogivalia* Jullien, 1882 and *Rectonychocella* Canu and Bassler, 1917, splitting it into two subfamilies, with *Antropora* the only genus in the Antroporinae. The adoption of Vigneaux's (1949) scheme would ease the problem; *Crassimarginatella* would fall within the Alderinidae Canu and Bassler, 1927, as would *Retevirgula*, but the exact familial assignment of *Parantropora* is as yet unclear.

The genus *Antropora* has a global distribution predominantly in the tropics. However, the type species, *A. granulifera* occurs from the warm temperate waters of the Atlantic to the tropical seas of the Pacific. Several other species, *A. typica*, *A. minor* and *A. tincta*, are found globally occurring in both warm temperate and tropical seas. The remaining species have more narrow geographical ranges; *A. subvespertilio* has a disjunct range in the Gulf of Mexico and the Philippines, whereas *A. erectirostra* has only been found from Sri Lanka. The two species of the new genus *Parantropora* appear to be limited to the tropical south-west Pacific, from the Indo-Malaysian region to the Great Barrier Reef and Fiji.

List of Fossil Species not covered in this paper.

Antropora daishakaensis Kataoka, 1957

Antropora elongata Kataoka, 1957

Antropora hataii Kataoka, 1957

Dacryonella minor Canu and Bassler, 1920

Dacryonella octonaria Canu and Bassler, 1917

Dacryonella octonaria minor Canu and Bassler, 1920

Dacryonella (*Homalostega*) *pavonia* (Marsson, 1887)

Dacryonella (*Reptescharinella*) *transversa* (d'Orbigny, 1852)

Dacryonella (*Homalostega*) *vespertilio* (Marsson, 1887)

Membrendoecium duplex Canu and Bassler, 1920

Membrendoecium lowei Canu and Bassler, 1920

Membrendoecium pyriforme Canu and Bassler, 1917

Membrendoecium rectum Canu and Bassler, 1920

Membrendoecium transversum Canu and Bassler, 1920

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References

ALLMAN, G. J. 1856. 'A Monograph of the freshwater Polyzoa, including all the known species, both British and Foreign'. Ray Society, London.

BROWN, D. A. 1948. Six new Recent and Tertiary genera of cheilostomatous Polyzoa from New Zealand. *Annals and Magazine of Natural History*, ser.12, vol.1: 108–122.

BROWN, D. A. 1952. 'The Tertiary cheilostomatous Polyzoa of New Zealand'. Trustees of the British Museum (Natural History), London. 405 pages.

BUSK, G. 1852. An account of the Polyzoa and Sertularian Zoophytes, collected in the voyage of the 'Rattlesnake' on the coast of Australia and the Louisaide Archipelago, etc. Appendix no. IV. In: *Narrative on the Voyage of H.M.S. Rattlesnake.* **1**. (Ed: MacGillivray, J.): 343–402.

BUSK, G. 1884. Report on the Polyzoa collected by H.M.S. Challenger during the years 1873–76. Pt.1. Cheilostomata. *Scientific Results of the Challenger Expedition (Zoology)* **10:** 1–126, 36 pls.

CALVET, L. 1907. Bryozoaires. *Expedition Scientifique 'Travailleur' et 'Talisman' 1880–1883*, **7:** 355–495.

CANU, F. 1900. Révision des Bryozoaires du Crétacé figurés par d'Orbigny. Cheilostomata. *Bulletin de la Société Géologique de France*, (3) **28:** 334–463.

CANU, F. & BASSLER, R. S. 1917. A synopsis of American Early Tertiary cheilostome Bryozoa. *Bulletin of the United States National Museum*, **96:** 1–87.

CANU, F. & BASSLER, R. S. 1920. North American Early Tertiary cheilostome Bryozoa. *Bulletin of the United States National Museum*, **106**, (Vol.1, text) xx + 879p., (Vol.2, plates) 162pls.

CANU, F. & BASSLER, R. S. 1928a. Fossil and Recent Bryozoa of the Gulf of Mexico Region. *Proceedings of the United States National Museum*, **72:** 1–199.

CANU, F. & BASSLER, R. S. 1928b. Bryozoaires du Brésil. *Bulletin de la Société des Sciences de Seine-et-Oise*, **9** (5): 1–100.

CANU, F. & BASSLER, R. S. 1929. Bryozoa of the Philippine region. *Bulletin of the United States National Museum*, **100:** 1–685.

CANU, F. & BASSLER, R. S. 1930. The Bryozoan Fauna of the Galapagos Islands. *Proceedings of the United States National Museum*, **76:** 1–78.

COOK, P. L. 1968a. Polyzoa from West Africa. The Malacostega Part 1. *Bulletin of the British Museum (Natural History), Zoology*, **16**(3): 113–160.

COOK, P. L. 1968b. Bryozoa (Polyzoa) from the coasts of tropical west Africa. *Atlantide Report*, **10:** 115–262.

CUFFEY, R. J. 1986. Phylum Bryozoa. *In*: 'Marine Fauna and Flora of Bermuda. A Systematic Guide to the Identification of Marine Organisms'. (Ed: Sterrer, W.) John Wiley and Sons: New York.

CUFFEY, R. J. & COX, R. S. 1987. Reef-Dwelling Bryozoans of Enewatak Atoll. *In*: 'The Natural History of Enewatak Atoll. Vol. 2, Biogeography and Systematics'. (Eds: Devaney, D. M., Reese, E. S., Burch, B. L. and Helfrich, P.) United States Department of Energy: Oak Ridge, Tennessee.

DAVIS, A. G. 1934. English Lutetian Polyzoa. *Proceedings of the Geologists Association, London*, **45**: 205–245.

FLEMING, J. 1828. 'A history of British animals, exhibiting their descriptive characters and systematical arrangement of the genera and species of quadrupeds, birds, reptiles, fishes, Mollusca, and Radiata of the United Kingdom'. Bell & Bradfute: Edinburgh.

GORDON, D. P. 1984. The Marine Fauna of New Zealand: Bryozoa: Gymnolaemata from the Kermadec Ridge. *Memoirs of the New Zealand Oceanographic Institute*, **91:** 1–198.

GORDON, D. P. 1986. The Marine Fauna of New Zealand: Bryozoa: Gymnolaemata (Ctenostomata and Cheilostomata Anasca) from the Western South Island Continental Shelf and Slope. *Memoirs of the New Zealand Oceanographic Institute*, **95:** 1–121.

GORDON, D. P. 1989. The Marine Fauna of New Zealand: Bryozoa: Gymnolaemata (Cheilostomida Ascophorina) from the Western South Island Continental Shelf and Slope. *Memoirs of the New Zealand Oceanographic Institute*, **97:** 1–158.

HARMELIN, J.-G. 1973. Les Bryozoaires des peuplements sciaphiles de Méditerranée: Le genre *Crassimarginatella* Canu (Chilostomes Anasca). *Cahiers de Biologie Marine*, **14:** 471–492.

HARMER, S. F. 1926. The Polyzoa of the Siboga Expedition. Part 2. Cheilostomata Anasca. *Siboga Expedition* **28D:** 183–501.

HASTINGS, A. B. 1930. Cheilostomatous Polyzoa from the vicinity of the Panama Canal collected by Dr. C. Crossland on the cruise of the S. Y. 'St. George'. *Proceedings of the Zoological Society, London*, **1929:** 670–740.

HAYWARD, P. J. 1988. Mauritian cheilostome Bryozoa. *Journal of Zoology, London*, **215:** 269–356.

HAYWARD, P. J. & RYLAND, J. S. 1995. Bryozoa from Heron Island, Great Barrier Reef. 2. *Memoirs of the Queensland Museum*, **38**(2): 533–573.

HINCKS, T. H. 1880a. Contributions towards a general history of the marine Polyzoa. I. Madeiran Polyzoa. *Annals and Magazine of Natural History*, ser.5, vol.**6:** 69–80.

HINCKS, T. H. 1880b. Contributions towards a general history of the marine Polyzoa. II. Foreign Membraniporina. *Annals and Magazine of Natural History*, ser.5, vol.**6:** 81–92.

HINCKS, T. H. 1882. Report on the Polyzoa of the Queen Charlotte Islands. *Annals and Magazine of Natural History*, ser.5, vol.**10**: 248–256; 459–471.

HINCKS, T. H. 1884. Contributions towards a general history of the marine Polyzoa. XII. Polyzoa from India (coast of Burmah). *Annals and Magazine of Natural History*, ser.5, vol.**13:** 356–362.

HINCKS, T. H. 1885. Contributions towards a general history of the marine Polyzoa. XIV. Polyzoa from New Zealand and Australia. XV. Cheilostomata – Miscellaneous. *Annals and Magazine of Natural History*, ser.5, vol.**15:** 244–257.

HINCKS, T. H. 1893. Contributions towards a General History of the Marine Polyzoa, 1880–1891. Appendix. *Annals and Magazine of Natural History*, ser.6, vol.**11:** 198–205.

d'HONDT, J.-L. 1985. Contribution à la systématique des Bryozoaires Eurystomes. Apports récents et nouvelles propositions. *Annales des Sciences Naturelles, Zoologie*, série 13, **7:** 1–12.

JULLIEN, J. 1888. Bryozoaires. *Mission scientifique du Cap Horn 1882–1883,* **6** (*Zoologie Part 3*): 92p, 15 pls.

KATAOKA, J. 1957. Bryozoa from the Daishaka Formation (Pliocene), Minami-Tsugaru-gun, Aomori Prefecture. *Transactions of the Palaeontological Society of Japan N.S.*, **28**: 143–153.

LAMOUROUX, J. V. F. 1812. Extrait d'un mémoire sur la classification des polypiers coralligènes non entièrement pierreux. *Nouveau bulletin scientifique de la Société Philosophique,* **3**: 181–188.

MACGILLIVRAY, P. H. 1882. Descriptions of new, or little known, Polyzoa. Part I. *Transactions and Proceedings of the Royal Society of Victoria,* **18**: 115–121.

MACGILLIVRAY, P. H. 1890. Descriptions of new, or little known, Polyzoa. Part XIII. *Transactions and Proceedings of the Royal Society of Victoria,* n.s. **2**: 106–110.

MACGILLIVRAY, P. H. 1891. Descriptions of new, or little known, Polyzoa. Part XIV. *Transactions and Proceedings of the Royal Society of Victoria,* n.s. **3**: 77–83.

MACGILLIVRAY, P. H. 1895. A monograph of the Tertiary Polyzoa of Victoria. *Transactions and Proceedings of the Royal Society of Victoria,* n.s. **4**: 1–166.

MARCUS, E. 1937. Bryozoarios marinhos brasileiros, 1. *Boletins da Faculdade de Filosofia, Ciencias e Letras, Universidade de São Paulo* 1, Zoologia, no.1: 1–224.

MARSSON, T. F. 1887. Die Bryozoen der weissen Schreibekreide der Insel Rügen. *Paläontologische Abhandlungen,* **4**: 1–112, pls 1–10.

MAWATARI, S. & MAWATARI, S. F. 1981. Studies on Japanese Anascan Bryozoa 6. Division Malacostega (4). *Bulletin of the Library Arts and Science Course, School of Medicine, Nihon University,* **9**: 23–61.

NORMAN, A. M. 1903a. Notes on the natural history of East Finmark. Polyzoa. *Annals and Magazine of Natural History,* ser.7, vol.**11**: 567–598.

NORMAN, A. M. 1903b. Notes on the natural history of East Finmark. Polyzoa. *Annals and Magazine of Natural History,* ser.7, vol.**12**: 87–128.

d'ORBIGNY, A. 1852. Recherches zoologiques sur la classe des Mollusques Bryozoaires. *Annales des Sciences Naturelles, Zoologie (3),* **17**: 273–348.

OSBURN, R. C. 1927. Bryozoa of Curaçao. *Bijdragen Tot De Dierkunde,* **182**: 123–132.

OSBURN, R. C. 1940. Bryozoa of Porto Rico with resume of the West Indian Bryozoan fauna. *Scientific Survey of Porto Rico and Virgin Islands. New York Academy of Science,* **16**(4): 321–486.

OSBURN, R. C. 1950. Bryozoa of the Pacific coast of North America. Part 1. Cheilostomata Anasca. *Allan Hancock Pacific Expedition,* **14**: 1–269.

POWELL, N. A. 1967. Bryozoa (Polyzoa) from the South Red Sea. *Cahiers de Biologie Marine,* **8**: 161–183.

PRENANT, M. & BOBIN, G. 1966. Bryozoaires. Cheilostome Anasca. *Faune de France,* **68**: 1–647.

RISTEDT, H. & HILLMER, G. 1985. The Cheilostomate Bryozoan Fauna from Shallow Waters of the Hilutangan Channel, Cebu, Philippines: Part 1. *The Philippine Scientist,* **22**: 133–143.

ROBERTSON, A. 1921. Report on a collection of Bryozoa from the Bay of Bengal and other eastern Seas. *Records of the Indian Museum,* **22**: 33–65.

RUCKER, J. B. 1967. Paleoecological analysis of cheilostome Bryozoa from Venezuela-British Guiana shelf sediments. *Bulletin of Marine Science,* **17**(4): 787–839.

RYLAND, J. S. & HAYWARD, P. J. 1977. British Anascan Bryozoans. *Linnean Society Synopses of the British Fauna,* New Series, **10**: 1–188.

RYLAND, J. S. & HAYWARD, P. J. 1992. Bryozoa from Heron Island, Great Barrier Reef. *Memoirs of the Queensland Museum,* **32**(1): 223–301.

SCHOLZ, J. 1991. Die Bryozoenfauna der philippinischen Riffregion Cebu. *Mitteilungen Géologisch-Paläontologisches Institut der Universität, Hamburg,* **71**: 253–403.

SILÉN, L. 1941. Cheilostomata anasca (Bryozoa) collected by Prof. Sixten Bock's expedition to Japan and the Bonin Islands, 1914. *Arkiv för Zoologi,* Band **33A.** No.12: 1–129.

SOULE, D. F., SOULE, J. D. & CHANEY, H. W. 1995. The Bryozoa. *In*: 'Taxonomic Atlas of the Santa Maria Basin and Western Santa Barbara Channel'. Vol. **13.** (Eds: Blake, J. A., Chaney, H. W., Scott, P. H. and Lissner, A. L.) Santa Barbara Museum of Natural History: Santa Barbara, California.

THORNELY, L. R. 1905. Report on the Polyzoa. In: *Report of the Pearl Oyster Fisheries, Gulf of Manaar (4). Supplementary Report.* Vol. **26.** (Ed: Herdman, W. A.): 279–429.

THORNELY, L. R. 1912. Marine Polyzoa of the Indian Ocean, from H.M.S. Sealark. *Transactions of the Linnean Society, London,* ser.2, Zool., vol.**15**: 137–157.

UTTLEY, G. H. 1951. The Recent and Tertiary Polyzoa (Bryozoa) in the collection of the Canterbury Museum, Christchurch. Part II. *Records of the Canterbury Museum,* **6**(1): 15–39.

VIGNEAUX, M. 1949. Révision des Bryozoaires néogènes du Bassin d'Aquitaine et essai de classification. *Mémoires de la Société Géologique de France,* **28**: 1–153, pls 1–11.

WATERS, A. W. 1898. Observations on Membraniporidae. *Journal of the Linnean Society, London (Zoology),* **26:** 654–693.

WATERS, A. W. 1906. Bryozoa from Chatham Island and d'Urville Island, New Zealand, collected by Professor H. Schauinsland. *Annals and Magazine of Natural History,* ser.7, vol.**17:** 12–23.

WATERS, A. W. 1909. Reports on the Marine Biology of the Sudanese Red Sea, from collections made by Cyril Crossland, M.A., B.Sc., F.Z.S.; together with collections made in the Red Sea by Dr. R. Hartmeyer – XII. The Bryozoa. Part 1. Cheilostomata. *Journal of the Linnean Society, London (Zoology),* **31:** 123–181.

WINSTON, J. E. 1982. Marine Bryozoans (Ectoprocta) of the Indian River Area (Florida). *Bulletin of the American Museum of Natural History,* **173:** 99–176.

WINSTON, J. E. 1986. An Annotated Checklist of Coral-Associated Bryozoans. *American Museum Novitates,* no. **2859:** 1–39.

THE SKULL OF DROMORNITHID BIRDS: ANATOMICAL EVIDENCE FOR THEIR RELATIONSHIP TO ANSERIFORMES

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MURRAY, P. F. & MEGIRIAN, D. 1998. The skull of dromornithid birds: anatomical evidence for their relationship to Anseriformes. *Records of the South Australian Museum* 31(1): 51–97.

Dromornithid cranial material from the mid and late Miocene Bullock Creek and Alcoota Local Faunae of the Northern Territory of Australia provides sufficient morphological data on which to base an opinion of their wider phylogenetic relationships. While the appendicular elements of dromornithid birds have been previously considered to show some similarities to those of living and extinct ratite birds, no common traits are evident on the cranium. The basipterygoid facets are large, flat surfaces closely applied to the basisphenoid rostrum. A transverse prokinetic craniorostral joint is present, the quadrates are mobile and the pterygopalatine joint is patent and condylar. Though many features of the dromornithid skull are unique to the family, structure and relations of the parasphenoidal rostrum and basipterygoid processes, morphology of the pterygopalatine joint, relations of the temporal fossa and form of the postorbital process, presence of large, oval fossae for the origin of the levators and protractors of the pterygoquadrate, basic form and presence of an anterolateral crest on the otic process of the quadrate and elongated post-tympanic crests and retroarticular processes indicate a close relationship with anseriform birds.

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Known since 1839, the gigantic birds of the family Dromornithidae have been described and classified almost exclusively on the basis of their postcranial anatomy (Rich 1979). Two partial skulls of *Genyornis newtoni* were described by Stirling and Zietz (1913) but with the exception of the quadrates and some parts of the upper and lower jaws, the specimens were in such poor condition that they only provided an indication of their shape and proportions. More recently, some undescribed dromornithid specimens recovered from the mid Miocene Bullock Creek Local Fauna and the late Miocene Alcoota Local Fauna of the Northern Territory, Australia, led Rich (1991:740) to conclude that '...the skull structure is so highly derived, it is difficult to associate with any known avian group.'

Dromornithids comprise five known genera and at least seven species of flightless birds endemic to Australia. Their diversity in size and form is comparable to that of New Zealand's Moas (Dinornithidae-Emeidae), ranging from Ostrich-sized *Ilbandornis* to the gigantic *Dromornis stirtoni* which weighed over a half a tonne (Rich 1979). Many of these species are represented by abundant and well-preserved post-cranial material, but the cranial and mandibular fossils, though not uncommon, have apparently been considered to be inadequate for description and analysis. Rich's (1979, 1980) detailed study of the postcranial skeleton of dromornithids shows that all species were ground-birds with keel-less sterna, extremely reduced wings, long flexible necks, and hind limbs adapted for cursorial locomotion, thus generally resembling large living ratites such as Emus, Ostriches and Rheas and extinct ratites such as Elephant birds and Moas.

Dromornithids are known from Eocene through to late Pleistocene sediments widely distributed in Australia (Vickers-Rich and Molnar 1996, Field and Boles 1998). Their diversity was apparently greatly diminished after the early to mid Pliocene, subsequent to which, the family is represented by only one species, *Genyornis newtoni*. Rich (1979) provides a detailed and interesting account of the history of discovery of dromornithids to which we refer the reader.

We describe, illustrate and compare some of the cranial material collected between 1985 and 1996 by Northern Territory Museum expeditions to the Bullock Creek and Alcoota fossil vertebrate fossil localities in the Northern Territory. We believe that these specimens provide sufficient anatomical information to identify their position within the current avian systematic framework. Because of the many unique and interesting features of the

dromornithid skull, we have briefly examined some aspects of its functional anatomy and have attempted to reconstruct the appearance as well as some aspects of the palaeobiology of the species. However, as the skulls of the Dromornithidae have not been previously described in detail, we have concentrated primarily on providing adequate anatomical detail for further analysis, pointing to certain areas in which this information may find application.

Key Words: Dromornithidae, avian cranial anatomy, ratite birds, *Diatryma*, Anseriformes, Anhimidae, avian paleobiogeography

Methods And Materials

Due to its extreme fragility, Bullock Creek dromornithid cranial material from Camfield Beds limestone was partially extracted with dilute acetic acid and finally prepared by hand. Alcoota Local Fauna dromornithids, extracted from Waite Formation silty and sandy sediments, were prepared in the field using Synocryl diluted in acetone. The dromornithid material was compared with the following specimens of extant species prepared using water maceration and ammonia methods: Struthioniformes, *Struthio camelus* (Ostrich) late embryo, 4-week old chick, 3-month old chick; *Dromaius novaehallandiae* (Emu) 6 week old chick, two adults; Galliformes, *Gallus gallus* (Domestic fowl) two-week old chick; *Megapodius reinwardt* (Orange-footed scrub-fowl) 1 hatchling, 1 adult; Anseriformes, *Anseranas semipalmata* (Magpie goose), *Anas* spp. (domestic ducks), *Anas superciliosa* (Pacific black duck), *Malacorhynchus membranaceus* (Pink-eared duck), *Anser sp.* (domestic gosling); Procellariiformes, *Puffinus tenurostris* (Short-tailed shearwater); Pelecaniformes, *Phalacrocorax sulcirostris* (Little black cormorant), *Pelecanus conspicillatus* (Australian pelican); Ciconiiformes, *Ardea sp.* (egret), *Threskiornis spinicollis* (Straw-necked ibis); Falconiformes, *Aquila audax* (Wedge-tailed eagle), *Falco berigora* (Brown falcon); Gruiformes, *Eulabeornis castaneoventris* (Chestnut rail), *Gallinula mortierii* (Tasmanian native-hen); Turniciformes, *Turnix velox* (Little button-quail); Charadriiformes, *Burhinus grallarius* (Bush stone-curlew), *Larus novaehollandiae* (Silver gull); Columbiformes, *Geophaps plumifera* (Spinifex pigeon), *Geopelia cuneata* (Diamond dove); Psittaciformes, *Calyptorhynchus banksii* (Red-tailed black cockatoo), *Cacatua roseicapilla* (Galah); Cuculiformes, *Centropus phasianinus* (Pheasant coucal); Strigiformes, *Ninox connivens* (Barking owl), *Ninox novaeseelandiae* (Southern boobook), *Tyto alba* (Barn owl); Coraciiformes, *Dacelo leachii* (Blue-winged kookaburra); *Eurystomus orientalis* (Dollarbird); Passeriformes, *Corvus sp.* (crow). Systematics of extant species follow Christidis and Boles (1995). Musculoskeletal relations were confirmed by dissection of the heads of Magpie goose and Chestnut rail preserved in alcohol. Observations on the development of basipterygoid processes in struthioniform, galliform and anseriform birds were made on embryos and chicks of Ostrich, domestic fowl and domestic goose. Comparative anatomical information was supplemented by Bock (1963), DeBeer (1957), Goodrich (1955), Heilmann (1926), Huxley (1867), McDowell (1948) Pycraft (1901) and Simonetta (1960).

Systematics

Class AVES

Subclass NEORNITHES

Order ANSERIFORMES

Family DROMORNITHIDAE Fürbringer 1888

Genus *Bullockornis* Rich 1979

Bullockornis planei Rich 1979

Referred material: cranium with basipterygoid processes P9464–106; cranial fragments P907–6, P9612–1, P9464–110, P9464–111; upper beak fragments, P9464–107, P9464–108, P907–28; ?nasal septum fragment, P87113–38; mandibles, P9464–112 , P9464–113, P9464–114, P9464–116; vomeropalatine fragment, P9464–115; left ?pterygoid fragment, P87103–43; right ?pterygoid fragment, P9464–101; left quadrates, P9464–100; P9464–118.

Locality: Bullock Creek, Northern Territory, Australia. Low limestone hill 1 km east of type section of Camfield Beds, 131°31'20"E, 17°07'S, Wave Hill (1:250 000), SE 52–8.

Lithic unit and age: Camfield Beds, middle Miocene.

Fauna: Bullock Creek Local Fauna.

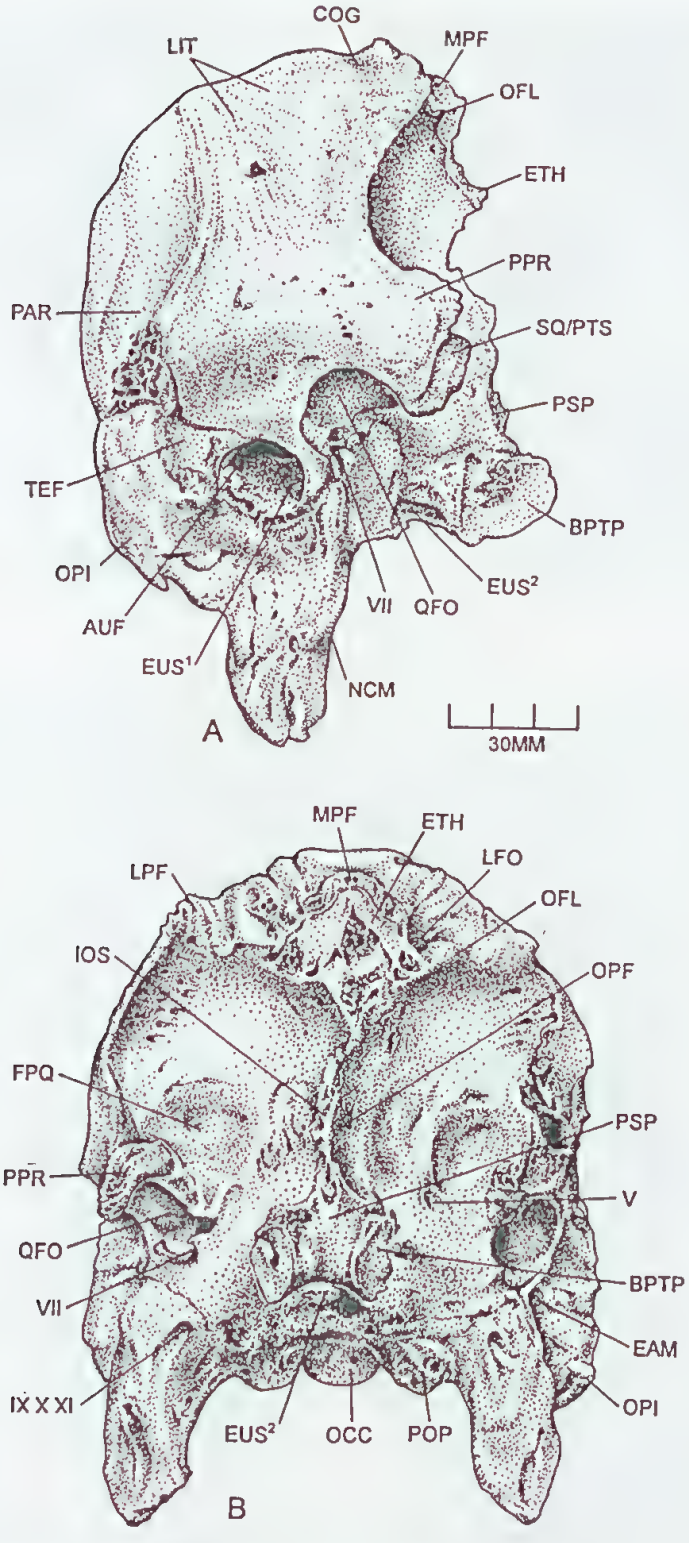


FIGURE 1. Cranium of *Bullockornis planei* (P9464–106); **A**, lateral aspect, **B**, anterior aspect. Abbreviations: AUF, auditory fenestra (*cavum auditivum*); BOC, basioccipital; BPTP, basipterygoid process; COG, coronal groove (capsule of cranio-rostral joint); EAM, external auditory meatus; ETH, ethmoid; EUS¹, external opening of eustachian canal; EUS², internal opening of eustachian canal; FMA, foramen magnum; FR, frontal; ?IPA, ?interparietal; IOS, interorbital septum; IX X XI, cranial nerves; LFO, lateral fossa or sinus; LIT, ligament tracts of cranio-rostral joint; LPF, lateral process of frontal; MPF, median process of frontal; NCM, "mastoid" process of opisthotic or neurocranio-mandibular process; OCC, occipital condyle; OFL, orbital flange; OPF, optic foramen; OPI, opisthotic (post-tympanic crest); PAR, parietal; POP, paroccipital process; PPR, postorbital process; PSP, parasphenoid; QFO, quadrate fossa; SOC, supraoccipital; SQ/PTS, squamosal and pterosphenoid components of zygomatic process; TEF, temporal fossa; V, foramen for trigeminal nerve (mandibular and maxillary branches) VII, foramen or notch for facial nerve; FPQ, fossa for mm. protractor quadratus and pterygoideus ('pterygoid fossa'); XII, hypoglossal nerve foramen.

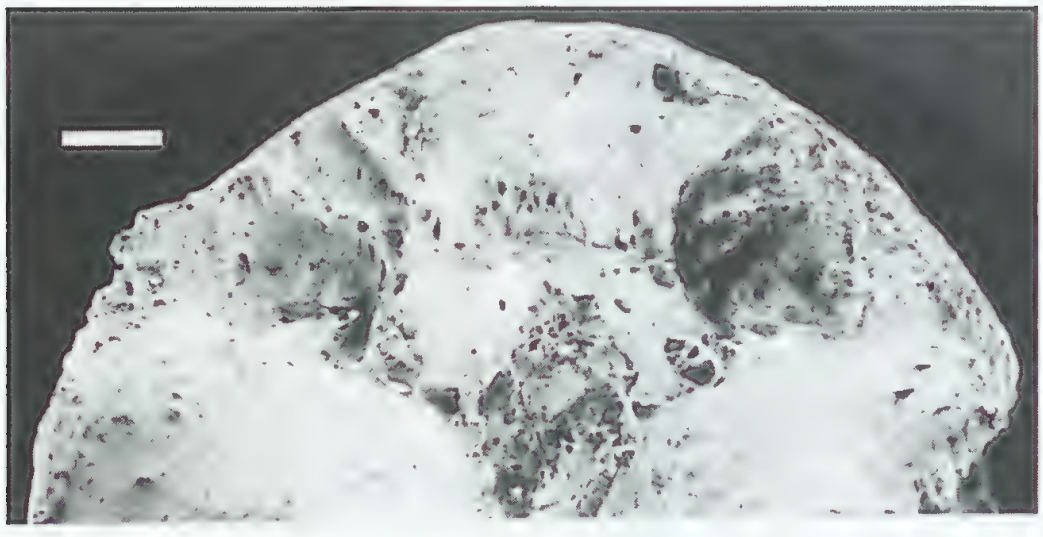


FIGURE 2. Photograph of frontal aspect showing cranio-rostral joint surface of *Bullockornis planei* (P9464–106). Scale bar equals 1 cm.

Description:

Cranium. The frontals, parietals, interparietal and occipitals form a nearly hemispherical vault over the orbits. (Fig. 1) The cranial walls are composed of a thin compactum overlying diploeic bone; attaining a thickness of 35–40 mm between the inner table of the endocranial cavity and the outer table of the frontal on the mid-sagittal plane. Only the posterior half of the orbital margin is known. In all specimens the orbit is a shallow C-shaped notch with a thin, slightly roughened margin marked by numerous foramina on the outer and inner surfaces. Dorsolaterally, a shallow fossa containing large emissaries is located about 20 mm medial to the orbital margin.

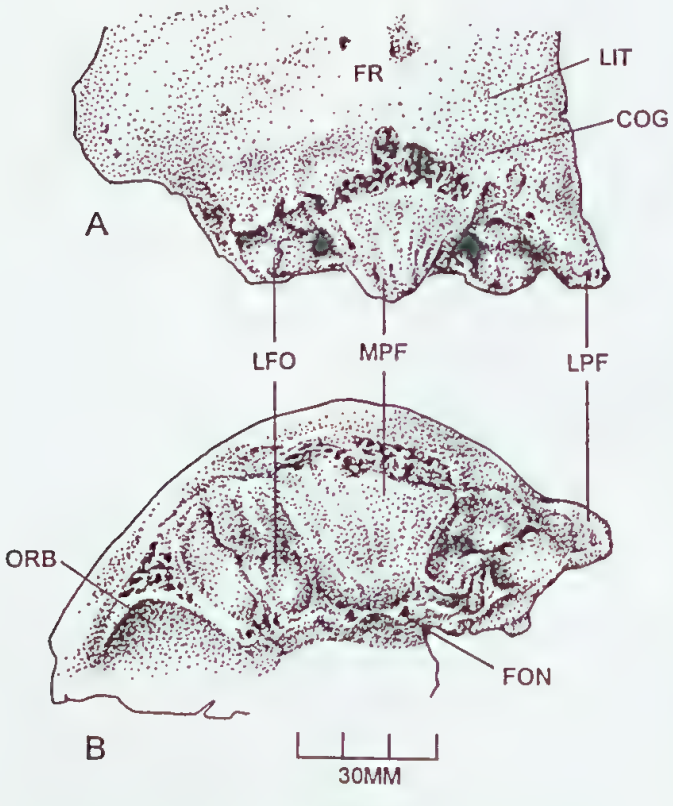


FIGURE 3. Drawing of cranio-rostral joint surfaces of *Bullockornis planei* (P907–6). A, dorsal; B, frontal aspect. Abbreviations: COG, coronal groove; FON, foramen for olfactory nerve; FR, frontal; LFO, lateral fossa; LIT, ligamentous tracts; LPF, lateral process of frontal; MPF, median process of frontal; ORB, orbit.

A series of circular indentations situated immediately behind the anterior frontal margin are associated with a ligamentous joint capsule, securing the fronto-ethmoid to the rostrum (Figs 1A, 2, 3A,B). The anterior orbital margin terminates in blunt process of variable width and length, forming the lateral wall of a pair of internally rugose, oval fossae situated on either side of a prominent, triangular median eminence of the frontal (Figs 1A,B, 2, 3A,B). A transverse groove at the base of the median frontal eminence corresponds to the dorsal margin of the ethmoid, which apparently encloses a median sinus, then narrows ventrally to merge with the interorbital septum. Breakage along these sutures occurs in all specimens in which the anterior part of the cranium is present.

The parasphenoidal crest of the interorbital septum is missing, but according to its section immediately anterior to the basipterygoid processes, it appears to have been a thin, V-shaped crest not much thicker than the interorbital plate. The optic and anterior lacerate foramina open on the dorsal margins of the orbital wall, separated by about 13 mm on either side of the interorbital septum (Figs 1B, 4A). Although variable in size and number, up

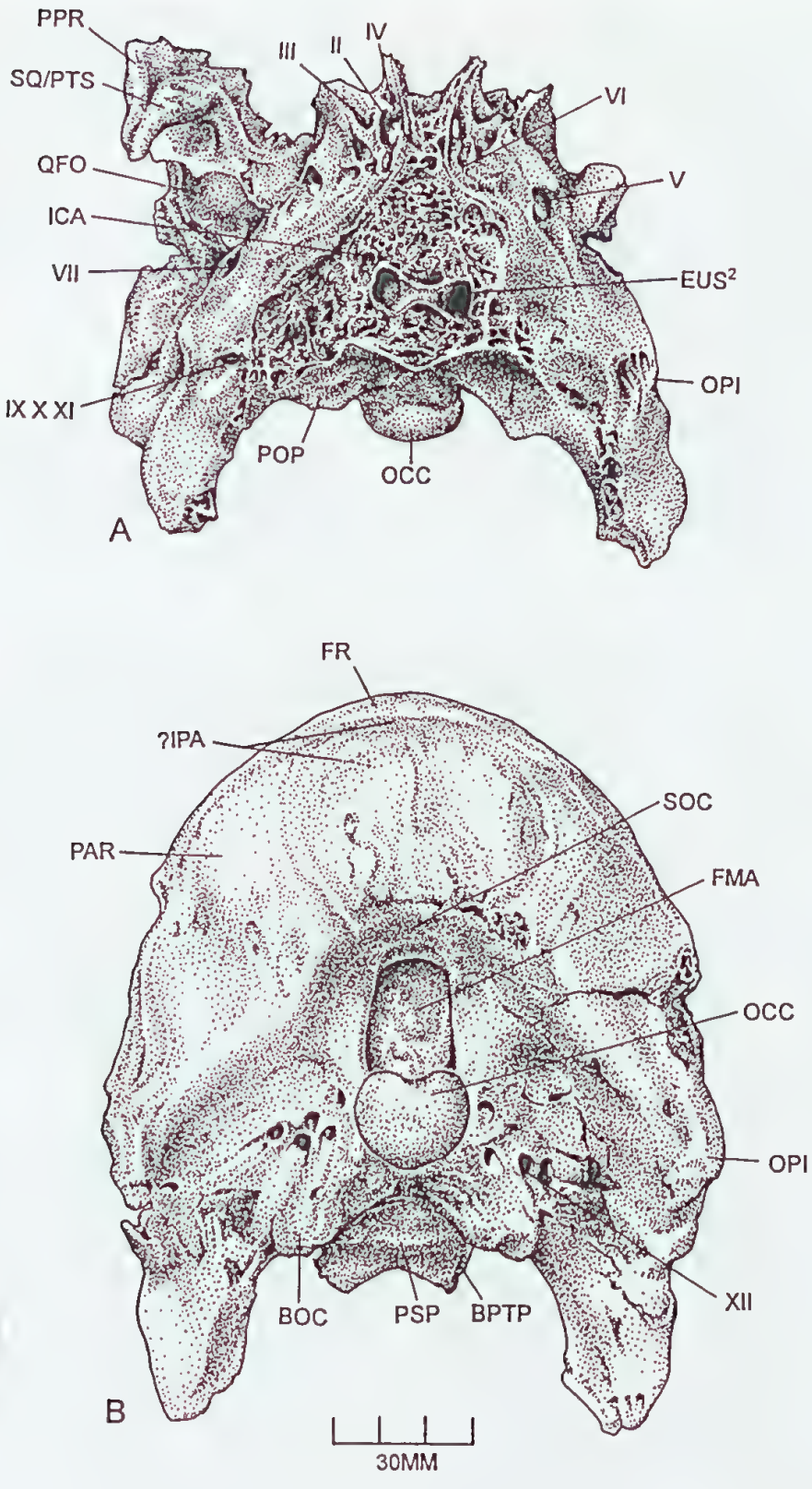


FIGURE 4. Cranium of *Bullockornis planei*; **A**, ventral aspect showing median position of conjoined eustachian canals (P907–6); **B**, posterior aspect (P9464–106). Abbreviations: EUS², internal eustachian canal opening; ICA, internal carotid artery foramen; II, optic nerve foramen; III, oculomotor nerve foramen; IV, trochlear nerve foramen; IX X XI, accessory, vagus and glossopharyngeal nerve foramen (posterior lacerate); LFO, lateral fossa (sinus) of frontal; LIT, ligament tracts of cranio-rostral joint capsule; LPF, lateral process of frontal; MPF, median process of frontal; OPI, opisthotic; ORB, orbit; POP, paroccipital process; PPR, postorbital process; QFO, quadrate fossa; SQ/PTS, squamosal/pterosphenoid components of postorbital process;V, trigeminal nerve foramen;VI, abducens nerve foramen; VII, facial nerve foramen.

to four small foramina surround the optic foramen. From anterodorsally to posteroventrally these are identified as: ophthalmic artery (dorsal notch in optic foramen) ophthalmic nerve (V^1), oculomotor nerve (III), abducens nerve (VI) and trochlear nerve (IV). A variable-sized foramen rotundum (V^2) opens immediately dorsoposterior to the abducens foramen; about 12 mm posterolateral to which is situated the large foramen ovale (V^3). On either side, about one centimetre lateral to external margin of the optic foramen are ~15 mm deep, oval pits about 15 mm x 20 mm wide representing the origins of the *mm. protractores et levatores quadratus + pterygoideus*. Extending ventrally from the posterolateral margin of these pits are short, broad postorbital processes composed of two fused elements (Figs 1A,B, 4A).

The inner element of this process appears to be composed of the squamosal eminence of the quadratic fossa and the laterosphenoid. Arising from the anterior margin of the quadrate fossa and widening distally, its terminal crest gives the appearance of having been twisted 90°. The inner (ventral) surface of the postorbital process is concave and functioned as an extension of muscle attachment area of the reduced temporal fossa. Closely applied to the laterosphenoid process is a thin, broad outer lamina of the posterior margin of the orbit that appears to arise from the lateral process of the squamosal, possibly overlapping the postorbital margin of the frontal. The fusion of these elements has displaced the temporal fossa posteroinferiorly to a circular depression extending from just above the auditory meatus, where the aponeurosis of the external adductor muscles originates from a strong crest, to the previously described pocket on the inferomedial side of the postorbital process.

The quadrate fossa is roundly oval, about 22 mm by 15 mm, with a smooth, solid articular surface. A slightly raised, oval articular eminence is visible in some individuals. A spinous process arises from the ventral margin for the anterior quadratic ligament which probably inserts into a long, deep groove on the anteromedial surface of the quadrate. The 20 mm diameter external auditory recess is approximately circular, enclosed in a deep, funnel-shaped orifice formed primarily by greatly expanded post-tympanic crests of the opisthotics. The eustachian and tympanic fenestrae, lying deep within the recess, are separated by a broad interfenestral process. The facial nerve passes through a variable foramen or notch situated near the posteroventral edge of the quadratic fossa. The large eustachian canals emerge confluently on the mid-line of the basitemporal plate, at the base of the parasphenoidal rostrum. Situated a short distance anterolaterally are the internal carotid foramina.

The basipterygoid or rostropterygoid (Weber 1993) facets are closely applied to the ventrolateral margins of the parasphenoidal rostrum. The smooth, 27 mm long by 19 mm wide, oval and slightly concave articular surfaces are situated 18 mm apart and protrude about 4 mm on either side of the eminence (Figs 1A,B, 6A,B). Shallow, arcuate grooves extend from the margins of the confluent eustachian openings to the posterior lacerate foramina, probably indicating the suture between the parasphenoid and basisphenoid. Posterolateral to the small basitemporal plate, the basioccipital is dominated by a pair of large conical paroccipital processes for the rectus capitus muscles. In some individuals in which the paroccipital processes are less prominent, deep oval fossae or rugose, elliptical muscle scars are present. A wide groove is formed between the paroccipital processes that continues forward onto the basisphenoid. Lateral to these are elongated, wing-like post-tympanic processes of the opisthotics. The bases of each, approximately 50 mm long neurocranio-mandibular process, bears a large posterior lacerate foramen (vagus foramen of Pycraft) on its anterior surface for nerves IX, X and XI.

The occipital surface of the cranium is deeply concave owing to the posterior sweep of the large post-tympanic crests of the opisthotics (Fig. 4B). Ventrolateral to the occipital condyle are multiple condylar (hypoglossal nerve) foramina emergent from deep condylar fossae. The occipital condyle is hemispherical, faintly notched on its dorsal margin and just perceptibly narrower ventrally. The foramen magnum is rectangular, about 17 mm wide by 25 mm high. The supraoccipital is broadly rectangular, above which a much smaller, though clearly defined oval structure, possibly representing an interparietal, is situated. Occipital fontanelles are absent. The parietals are crescentic, wedge-shaped bones meeting dorsally above the interparietals and bounded anteriorly by a strong lambdoidal crest. The suture of the anteroinferior process of the parietal is indistinct but appears to have sent a short process anteriorly over the squamosal. The frontal is short anteroposteriorly, narrowing anteriorly above the orbits, where it terminates in a blunt lateral process or eminence.

Endocranial cavity: The endocranial fossa is best represented on P907-6, in which the cranium is

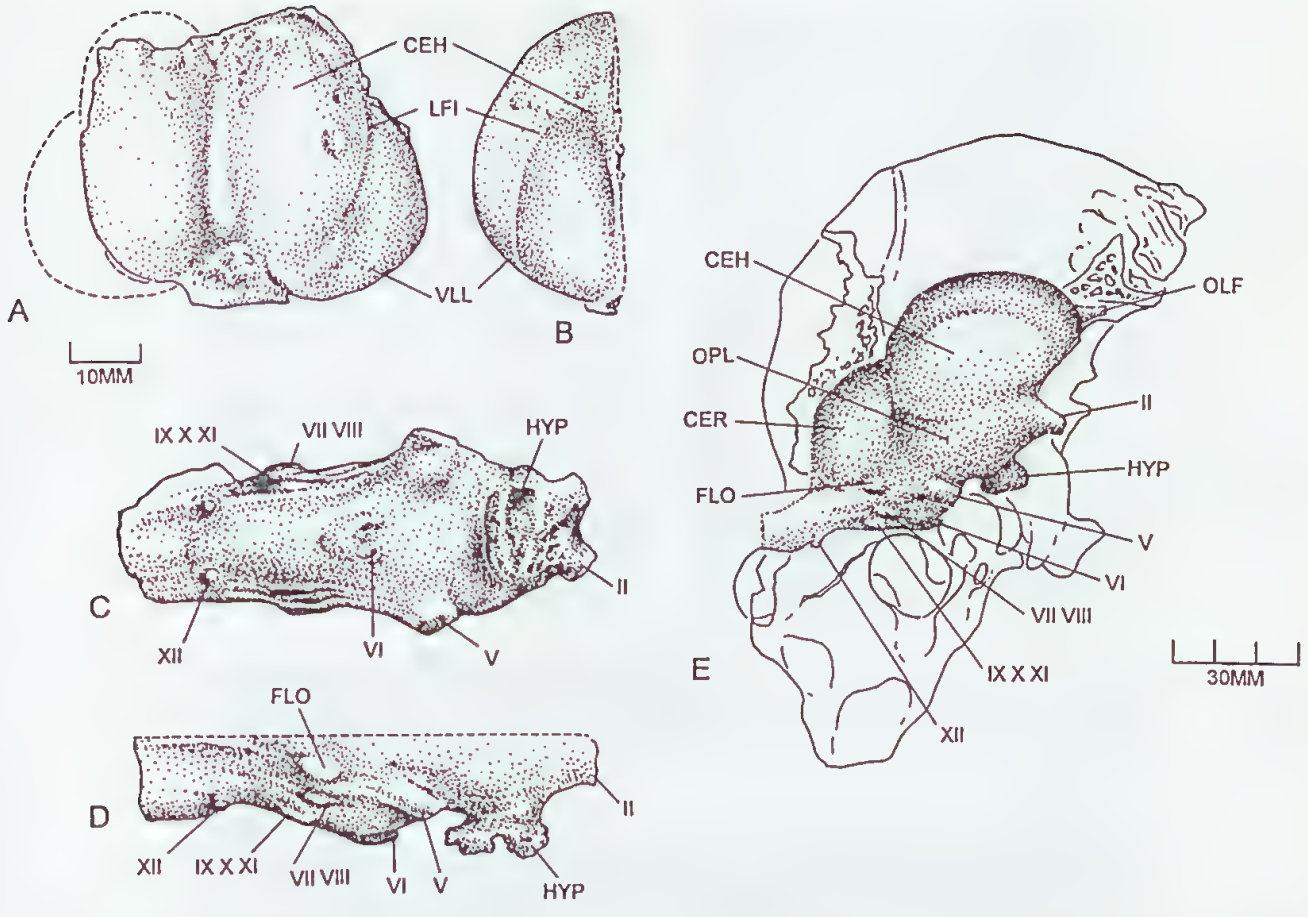


FIGURE 5. Endocranial structure of *Bullockornis planei* (P907–6); **A & B**, endocast of cerebral hemispheres, dorsal and lateral views; **C & D**, endocast of brainstem, ventral and lateral views; **E**, lateral aspect of reconstructed endocranial cavity. Abbreviations: CEH, cerebral hemisphere; CER, cerebellum; FLO, flocculus; HYP, hypophysis; II, optic nerve; IX X XI, accessory, vagus and glossopharyngeal nerve stumps; LFI, lateral fissure; OLF, olfactory nerve; OPL, optic lobe; V, trigeminal nerve stump; VI, abducens nerve stump; VII VIII, facial and acoustic nerve stumps; VLL, ventrolateral lobe of cerebrum; XII, hypoglossal nerve.

broken in half along the horizontal plane (Fig. 5A–E). A few millimetres of the base of the cerebral hemispheres are missing from the endocast, as the two pieces are slightly warped along the contact and do not join perfectly. The dimensions of the cerebral fossa are 44 mm long by 70 mm (estimated) wide and approximately 25 mm deep. The cerebral hemispheres are large, with the ventrolateral lobe greatly expanded transversely (Fig. 5A,B). The optic lobes are relatively small and tucked-in beneath the cerebral hemispheres (Fig. 5E). The brainstem is broad, considerably expanded at the base of the optic lobes to just behind the trigeminal stubs.

The hypophyseal fossa (*sella turcica*) is oval 12 mm x 9 mm by about 10 mm deep. The internal walls of the floor of the fossa of P907–6 have been breached resulting in a ragged cast (Fig. 5C,D). In P9612–1, where it is undamaged, it is circular, about 12 mm in diameter. The optic foramina commence immediately anterior to the *tuberculum sellae*, diverging laterally on either side of a 10 mm wide septum. The internal carotid foramen opens immediately anterior to the chiasmic sulcus. The trigeminal foramina are large 7 mm by 5 mm orifices situated 7 mm posterolateral to the margin of the hypophyseal fossa. Ventral to the trigeminal stubs is a broad pontine flexure, at the base of which is are the stubs of the abducens nerves. The internal auditory meatus for the facial and acoustic nerves is located in the ventral wall of the pro-otic 10 mm posterior to the trigeminal orifice. A large floccular fossa is located about 5 mm posterosuperior to the internal meatus, posteroventral to which is the large, slit-like foramen for nerves IX, X and XI. The nerve XII is located about 6 mm posterior to the former. Overall proportions of the medullary fossa are quite variable. It is short and broad in P9612–1 and long and narrow in P907–6.

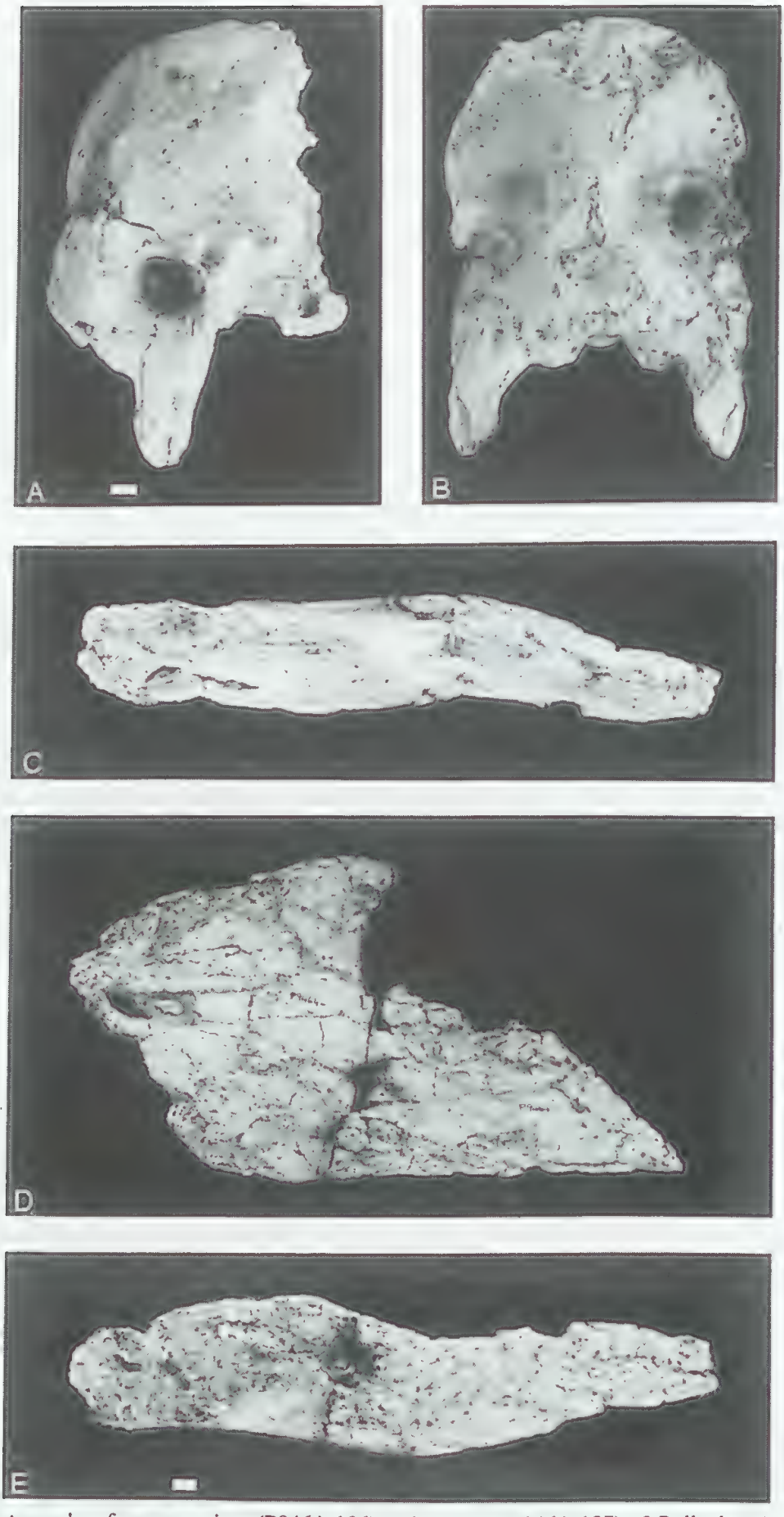


FIGURE 6. Photographs of neurocranium (P9464–106) and rostrum (P9464–107) of *Bullockornis planei*; **A** lateral aspect of neurocranium; **B** frontal aspect of neurocranium; **C**, upper beak, dorsal aspect; **D**, upper beak, lateral aspect; **E**, upper beak, palatal aspect; scale=1cm interval.

Rostrum. The rostrum or upper beak of *Bullockornis* is represented by a fragment 325 mm long, 174 mm deep and 58 mm maximum width (Figs 6C–E, 7A–C). The anterodorsal surface and about 25 mm of the tip of the beak are missing from the specimen. The beak is laterally compressed and extremely narrow. The culmen is a thin, arching crest about 10 mm wide at the apex, thickening gradually to about 21 mm width above the level of the external nares. In section, the beak is narrowly triangular with an elliptical internal cavity. A septal process in not apparent in mid-section. The palatal surface is shallowly concave posteriorly, becoming slightly more V-shaped in the anterior half. The palate is solid throughout, lacking a median palatal fenestra, though an imperforate elliptical fossa is present. The maxillopalatines are fused across the midline. The distal palatines are expanded into bulges of spongy bone that meet in the median sulcus anterior to the internal nares. Posteriorly, the palatines narrow into deep, vertical crests which have been crushed inwards on the specimen, obscuring other details in the region. A rhinothecal groove commences behind the decurved section of the tip: anteriorly as a narrow, ventrally-directed, U-shaped sulcus; posteriorly becoming wider, shallower and more laterally-directed. The width and angle of this groove is the reciprocal of the gnathothecal crest of the

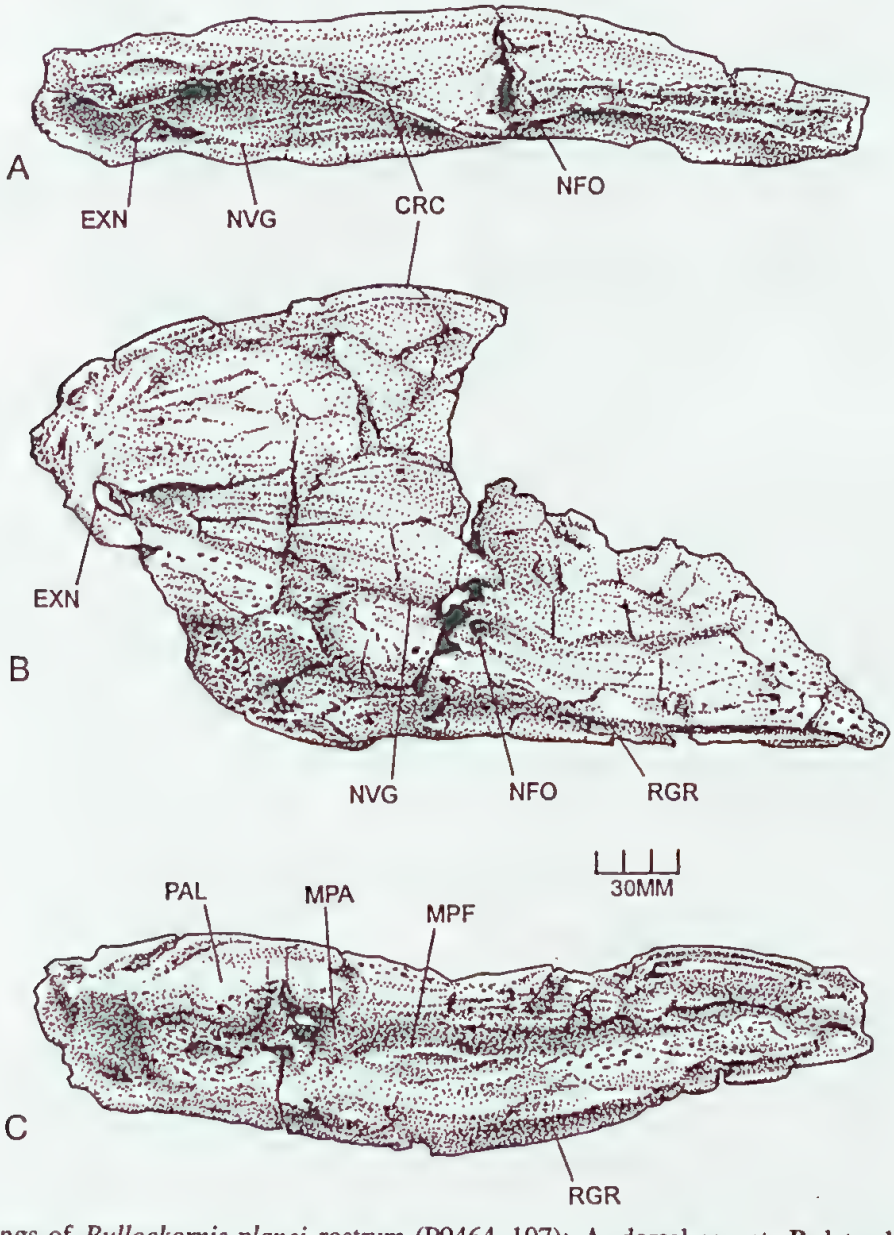


FIGURE 7. Drawings of *Bullockornis planei* rostrum (P9464–107); **A**, dorsal aspect; **B**, lateral aspect; **C**, palatal aspect. Abbreviations: CRC, crest of culmen (premaxilla); EXN, external nares; MPA, maxillopalatine; MPF, median palatal fossa; NFO, foramen in prenarial furrow; NVG, neurovascular grooves in prenarial furrow; PAL, palatine; RGR, rhinothecal groove.

mandible, that considerably overlaps the posterior half of the upper surface when the jaws are matched.

The upper edge of the rhinothecal groove extends to below the base of the maxillojugal contact, where it is about 35 mm wide. Immediately above the rhinothecal groove, the premaxillo-maxillary surface slants inwards at about 45° to vertical, continuing at this angle to meet an oblique sulcus that originates from the anterior margin of the external nares (Fig. 7B). This sulcus or prenarial furrow, (somewhat exaggerated by cracks) is the lowest of several, two or perhaps three, large tracts of fine grooves, predominantly representing the sensory branches of the maxillary nerve, that pass out of the external nares. The sulcus descends anteriorly to a tear-drop shaped (7 mm x 10 mm) aperture situated 42 mm above the tomial margin which appears to represent a large vascular foramen. The posterior surface of the beak is gently convex anterior to the nares, becoming flatter and very compressed dorsally. The external nares are holorhinal, oval openings about 18 mm by 30 mm. The cranial margin of the nares is directed posterolaterally in anticipation of the widening of the fronto-lachrymal facies.

The tip of the beak is slightly decurved in this species, as indicated by P907–28, a distal fragment retaining 42 mm of the ventral marginal profile, and P9464–108 which retains all but the tomial margin. Contours on this and the larger fragment suggest that although the mid to posterior dorsal surface of the beak is sharp and aquiline, the anterodorsal margin progressively widens, so that the tip appears rounded-off in palatal aspect. The dorsal outline of the beak appears to have been a smooth continuation of the arching profile of the culmen, as indicated by the beak fragment of *Dromornis stirtoni* (Fig. 15A, C). Unfortunately, the posterodorsal part of the culmen is broken off short of the frontal contact. A fragment (P87113–38) possibly representing the ethmofrontal contact is from a smaller individual or another species of dromornithid. The outer lamina of its extremely compressed lateral surfaces is broken above the narial aperture revealing the nasal septum. The posterior edge of the nasal septum bears a narrow ligmentous or membranous groove bordered by irregular crests. Dorsally, the groove expands into an oval, concave surface bordered by thin crests. Posteriorly, on either side of the septum, are deep grooves that probably represent the internal, dorsal margins of the nares. The outer lamina of the bone is broken just above the expansions of the prefrontal crests and narial margins.

Palate and quadrate. A left quadrate (P9464–100) retains all but the distal end of the orbital process and the lateral surface of the quadratojugal facet and external articular surface (Figs 8A–F, 9A,B). The body of the quadrate is broadly rectangular

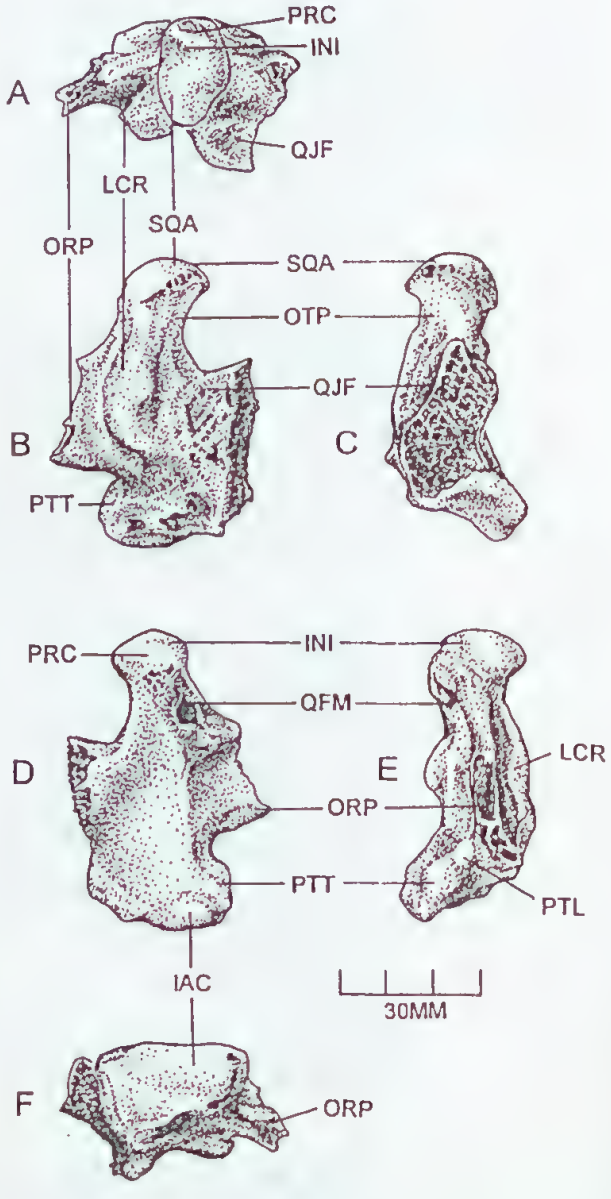


FIGURE 8. Left quadrate of *Bullockornis planei* (P9464–100); **A**, dorsal aspect; **B**, anterolateral aspect; **C**, posterolateral aspect; **D**, posterior aspect; **E**, anterior aspect; **F**, ventral aspect; note simple, rounded head of mobile (strepsostylic) quadrate. Abbreviations: IAC, internal articular condyle; INI, intercondylar incisure; LCR, lateral crest; ORP, orbital process; OTP, otic process; PTL, pterygo-quadrate ligament scar; PRC, pro-otic condyle; PTT, articular tubercle for pterygoid; QFM, quadrate foramen; QJF, articular facet for quadratojugal; SQA, squamosal articular surface or condyle.

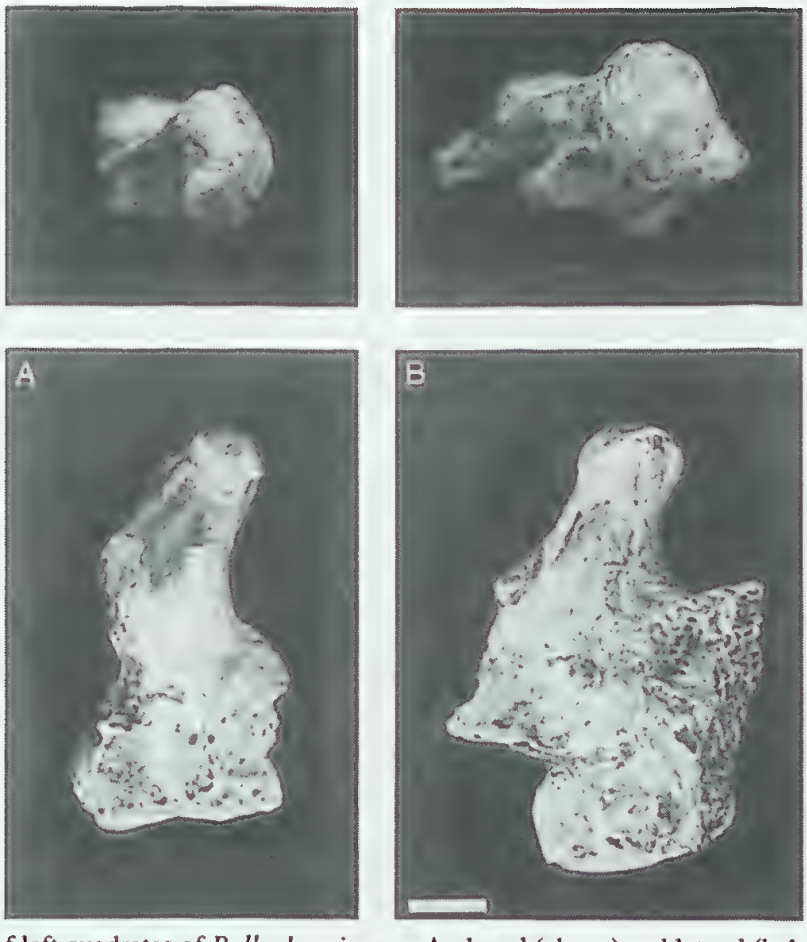


FIGURE 9. Photograph of left quadrates of *Bullockornis* spp., A, dorsal (above) and lateral (below) views of P9464–118; B, dorsal and lateral views of P9464–100; scale=1cm interval.

and about 15 mm thick. Its 60.0 mm long axis is curved posteriorly resulting in concave posterior and convex anterior surfaces. The otic process is stout and strongly buttressed mediolaterally by crests from bases of the orbital and quadratojugal processes. A single round, 4.0 mm diameter pneumatic foramen is present on the posterior surface 14 mm below the squamosal articular condyle or head. The broadly oval 19.0 mm x 15.0 mm head presents a smoothly rounded surface, the intercondylar incisure only faintly indicated. The pro-otic condyle is reduced to about 1/3 the size of the squamosal condyle and so weakly differentiated as to be easily dismissed.

A 25 mm long by 10 mm wide crest extends down the anteromedial side of the otic process, overhanging on its medial side, a deep ligamentous groove. The anterolateral surface of the crest represents the origin of the *m. adductor mandibularis externus profundus*. Posterolateral to the crest is a large, oval facet for the quadratojugal. Judging from the steep ascent of the dorsal margin of the facet, a well-developed posterior buttress was present. The base of the orbital process is about 25 mm deep and 5 mm thick. It appears to have been a broad, falcate flange. The posterior surface of the orbital process is shallowly concave. On its dorsoposterior margin, immediately below the quadrate foramen is a triangular ligament scar that corresponds to the posterior ligament of the quadrate, originating from a low tubercle on the posterointernal margin of the quadrate fossa. A low crest on the deeply concave posteroexternal margin of the otic process received the anterior cartilage of the meatal arch.

The anteromedial margin of the quadrate is notched between the base of the orbital process and the pterygoid tuberosity for a ligament and the dorsal process of the proximal pterygoid articular surface. The pterygoid tuberosity is an oval, 12 mm by 9 mm condylar process situated dorsomedial to the internal articular condyle. The internal articular condyle is elongated and narrow, 22 mm by 10 mm, separated from the largely missing lateral articular condyle by a flat, triangular surface. The corresponding lateral articular surface of the mandible indicates that the lateral condyle was broader than the medial.

Left quadrate P9464–118 is basically similar to P9464–100, though about 15% smaller, and

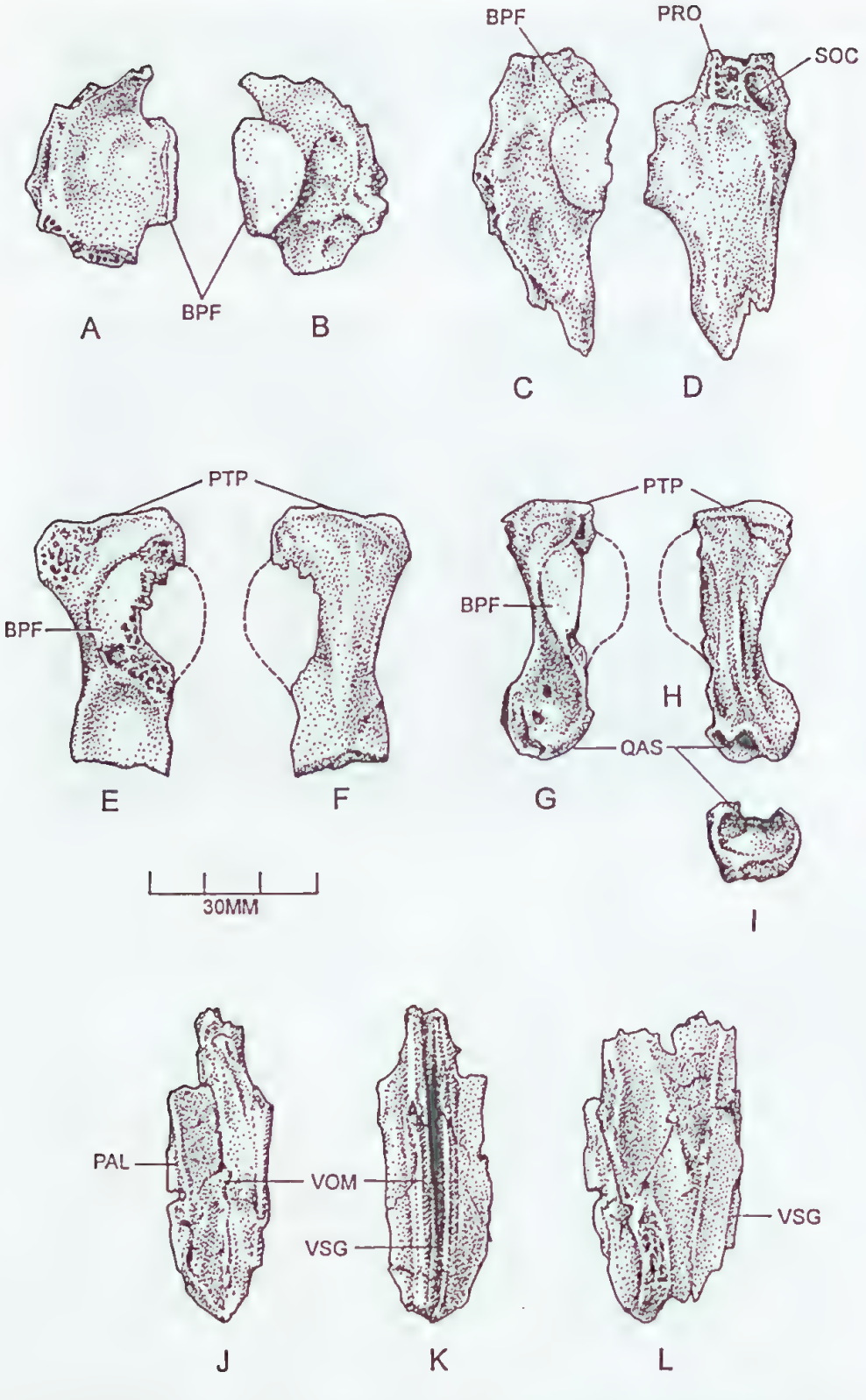


FIGURE 10. Palatal elements; **A** & **B**, ventral and dorsal views of right ?pterygoid fragment of *Bullockornis planei* (P9464–101); **C** & **D**, left dorsal and ventral views of left ?pterygoid fragment of *Bullockornis planei* (P87103–43); **E** & **F**, dorsal and ventral views of distal fragment of left pterygoid of *Dromornis stirtoni* (P98114); **G** & **H**, dorsal, ventral and proximal views of left pterygoid of *Ilbandornis sp.* (P98115) the joints are mobile, synovial and the fossa for the *mm. protractor + levator pterygoideus* is well-developed; **J–L**, ventral, dorsal and proximal views of vomeropalatine fragment of *Bullockornis planei* (P9464–108); the vomer forms a sliding joint on the parasphenoidal rostrum. Abbreviations: BPF, basipterygoid facet; PAL, palatine; PRO, ?base of palatine articular process; PTP, pterygoplatine articular surface; QAS, articular surface for quadrate; SOC, ?articular socket for palatine; VOM, vomer; VSG, vomeroseptal groove.

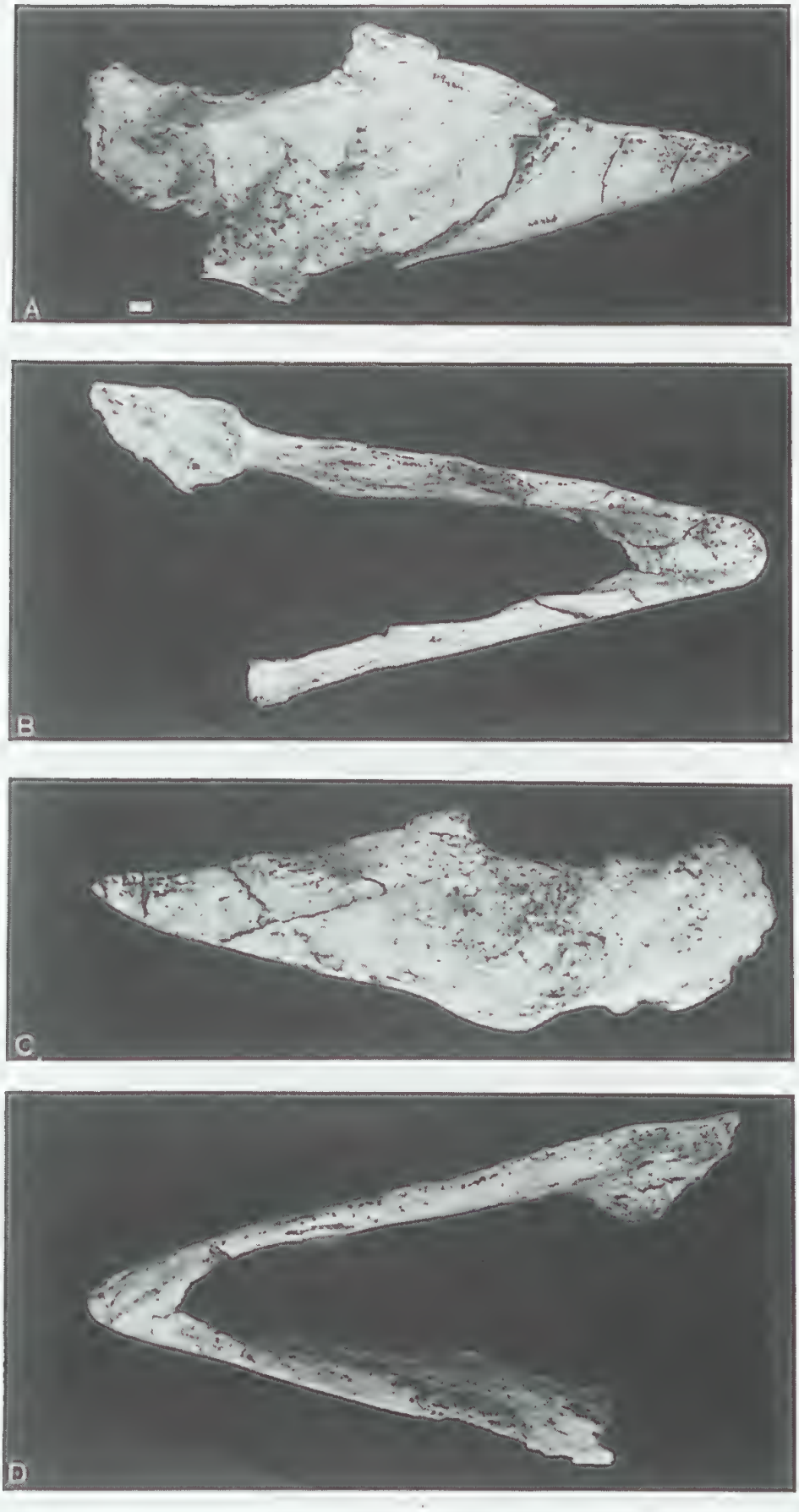


FIGURE 11. Photographs of partial mandible of *Bullockornis planei* (P9464–112); **A**, right lateral aspect; **B**, dorsal aspect; **C**, left lateral aspect; **D**, ventral aspect; scale=1cm interval.

differing in certain details sufficiently perhaps, to belong to one of the other species of *Bullockornis* (Fig. 9A). In this specimen, the intercondylar incisure is more distinct, though shallow and not sharply demarcated. The groove divides the curved, rectangular proximal articular surface into approximately equal parts, the pro-otic condyle being slightly shorter transversely than the squamosal condyle. The adductor process (lateral crest) is well-developed but less massive than in P9464–100 (Fig. 9A,B) and the dorsal crest of the orbital process extends further proximally to merge with the base of the pro-otic condyle.

Pterygoid?. Two fragments preserving little more than the basipterygoid articular facets may represent pterygoids of *Bullockornis* (Fig. 10A–D) The ventral surfaces are marked by a shallow fossa. Dorsally a wide sulcus commences lateral to the basipterygoid facet. A rugose crest extends along the lateral margin. The basipterygoid facets are flat, D-shaped surfaces, considerably off-set to the medial side of the distal end of the shaft. They are similar in size and shape in both specimens: P9464–101 is 20 mm by 14 mm and P87103–43 is 23 mm by 14 mm. P9464–101 preserves an oval 9 mm by 4 mm socket that may represent part of the palatine articular surface. The ventral process is broken off on both specimens. If these are correctly identified as pterygoids, they are relatively broader and thicker than the undoubted pterygoids of *Dromornis* and *Ilbandornis* (Fig. 10E–I) and differ in possessing a small socket joint with the palatine (Fig. 26A–I).

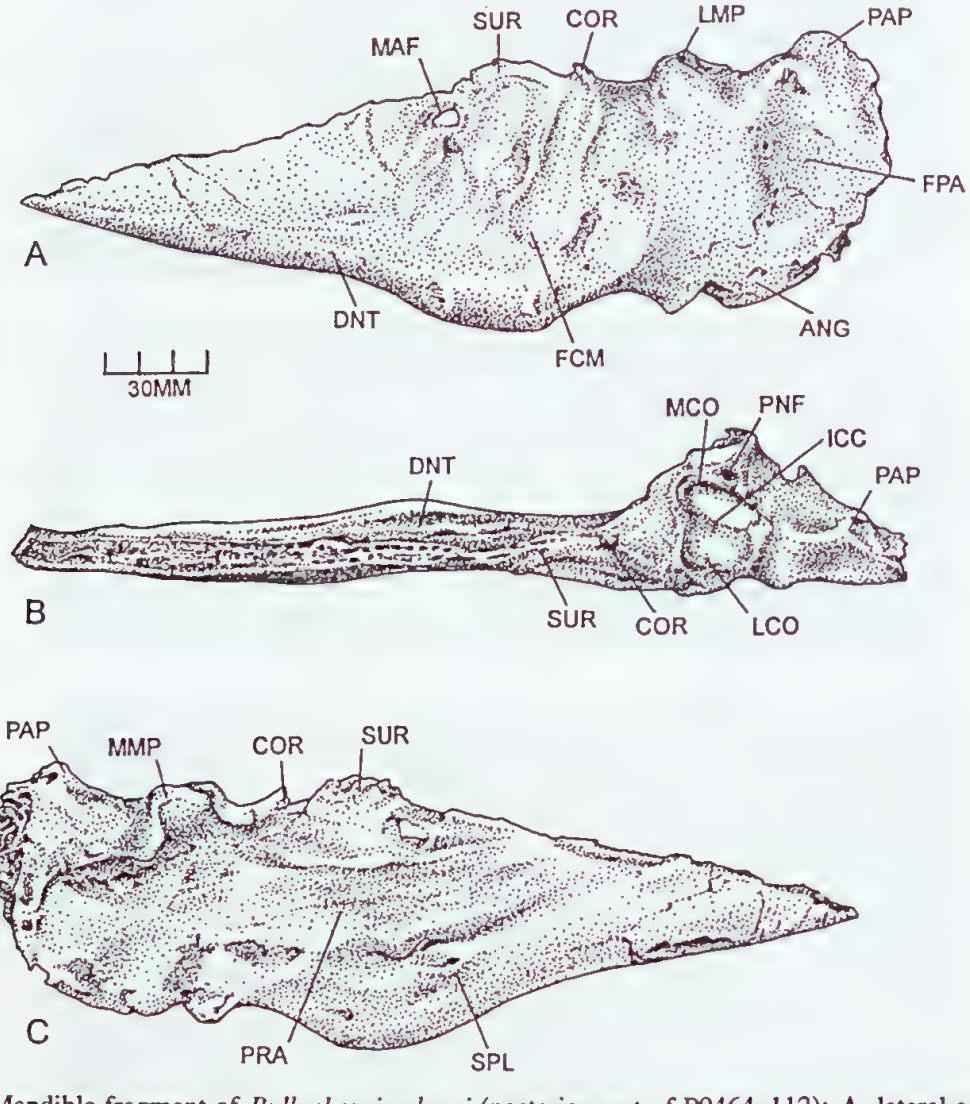


FIGURE 12. Mandible fragment of *Bullockornis planei* (posterior part of P9464–112); **A**, lateral aspect; **B**, dorsal aspect; **C**, internal aspect. Abbreviations: ANG, angular; COR, coronoid; DNT, dentary; FCM, fossa for external craniomandibular adductors; FPA, fossa for m. pterygoideus anterior; ICC, intercotylar crest; LCO, lateral cotyla; LMP, lateral mandibular process; MAF, mandibular fenestra; MCO, medial cotyla; MMP, medial mandibular process; PAP, postarticular (retroarticular) process; PNF, pneumatic foramen; PRA, prearticular; SPL, splenial; SUR, surangular.

Vomeropalatine?. The precise position and orientation of the bones represented by an isolated 56 mm long fragment (P9464–115) of fused palatal mid-line elements are unknown (Fig.10J–L). The fragment is triradiate in section with a median suture dividing a broadly U-shaped grooved surface, opposite of which is a deep longitudinal median crest bearing a narrow V-shaped slot. The external margins of the slotted crest are smooth and shallowly concave. The internal surfaces of the slot are also smooth and clearly indicative of a sliding joint. The median process probably represents the fused prevomers; its median slot articulating with the parasphenoid and the U-shaped sutured surfaces representing the hemipterygoid component of the palatines. A crest along the broken lateral margin probably represents the internal edge of the palatine. This interpretation seems in accord with the deep palatal structure of dromornithids in which the hemipterygoids and palatines might form the dorsoposterior margin of the internal nares similar to the equivalent region in parrots.

Mandible. Several large fragments of the mandible have been recovered, sufficient to fully reconstruct its overall shape (Figs 11A–D, 12A–C). The wedge-shaped dentaries are deep and flat-sided, with a slightly concave dorsal marginal profile, descending from posterior to anterior at an angle of about 30° relative to the ventral border. The surangular is a low, sinuous crest ascending towards the back of the deep posterior dentary margin at about 40°. The broad and robustly constructed articular is divided into lateral and medial cotylar surfaces by a low, but distinct intercotylar crest. Corresponding processes are present on either side (Fig. 12A–C). The internal mandibular process forms a C-shaped crest around the anteromedial margin of the articular groove, thickening posteriorly into a broad triangular tuberosity surmounted by a distinct facet. The pneumatic foramen is large. The external or lateral mandibular process is a prominent, rounded tuberosity. The long axis of the articular fossa is directed anteromedially and is slightly inclined posteriorly. The lateral cotyla is enclosed anterolaterally by a crest of the lateral mandibular process. The elongated, oval 29 mm by 15 mm medial cotyla is much deeper and considerably longer than the external one (21 mm x 17 mm).

The postarticular process is long and deep, terminating dorsally in an upturned conical eminence. A considerable part of the postarticular process is missing from the illustrated specimen. The internal surface is deeply notched to accommodate the large post-tympanic crests and neurocranio-mandibular process. The coronoids are small but distinct projections arising from a low lateral crest. The surangular forms a low sinuous crest, at the base of which is a small mandibular fenestra. The angular suture is visible on P9464–112, trending horizontally about 40 mm above the inferior border. The prearticular forms a shelf-like horizontal crest extending along the base of the surangular. The ventral profile of the mandible is deeply notched immediately posterior to the dentary-splenial articulation resulting in a

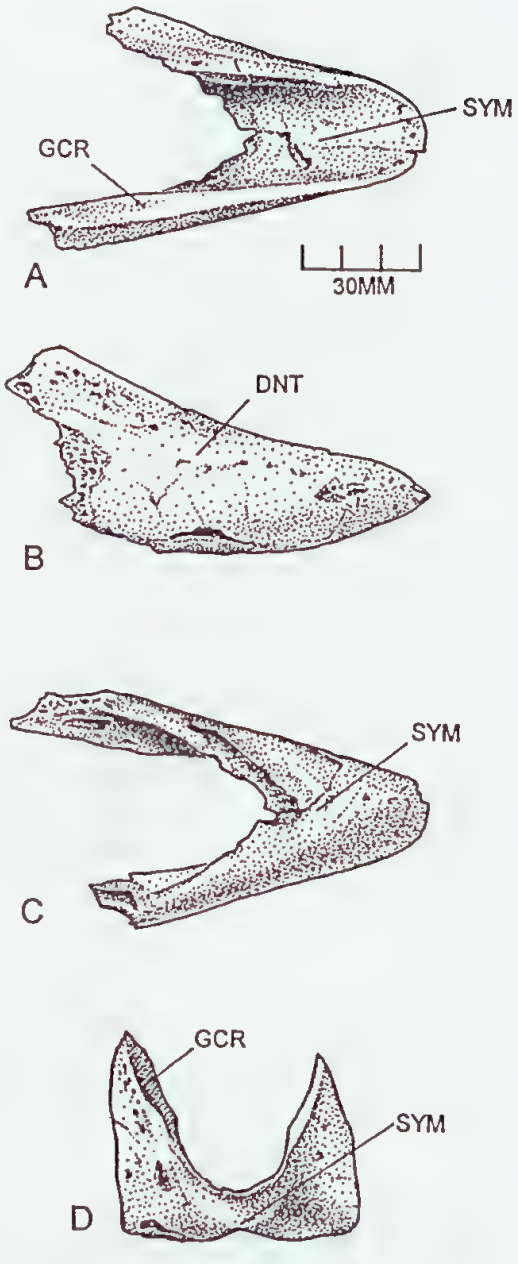


FIGURE 13. Dentary fragment of *Bullockornis planei* (P9464–113) showing form of the tip; **A**, dorsal aspect; **B**, lateral aspect; **C**, ventral aspect; **D**, anterior aspect. Abbreviations: DNT, dentary; GCR, gnathothecal crest; SYM, symphysis.

large, rounded gonial eminence. The splenial border is thick and rounded.

The dentary symphysis is fused, forming a U-shaped, scoop-like termination (Figs 11B–D, 13A–D). The ventral surfaces of the anterior portions of the mandibular rami are smooth, with no indication of an anteroposterior groove. Externally, the bases of the rami turn abruptly upwards from the ventral surface of the symphysis lending a decidedly slab-sided appearance to the region. The rami extend posteriorly in a long, narrow parabola, the longitudinal axis of each ramus being nearly straight. A thick internal gnathothecal crest commences about 40 mm posterior to the anterior margin of the tip. The profile of the tip is convex, corresponding to the concave, overhanging profile of the margin of the tip of the upper beak. In overall form, each hemimandible is deep, robustly constructed and scimitar-like. The external adductor muscle scar forms a deep circular fossa extending down to the inferior border and for an equivalent distance anteroposteriorly. Three distinct muscular ridges are present within the fossa reflecting considerable muscular differentiation of the craniomandibular adductors.

?*Bullockornis* sp.

Referred material: Occipitals, P87103–44, P8695–273, P8765–1, P9464–109.

Locality: Bullock Creek, Northern Territory (additional data as for *Bullockornis planei*).

Lithic unit and age: Camfield Beds; middle Miocene.

Fauna: Bullock Creek Local Fauna.

Description:

Occipital. Four occipital fragments represent a smaller dromornithid, presumably belonging to the unnamed Bullock Creek LF species described by Rich (1979) as ?*Bullockornis* sp. These are distinguished from the same region of the cranium of *Bullockornis planei* by their much smaller size and transversely broader occipital condyle with a more flattend dorsal margin. A circular fossa situated ventral to the base of the occipital condyle is a distinctive feature. The paroccipital processes are weakly developed and project ventrally rather than posteriorly. The basioccipital is flatter and broader than in *Bullockornis planei*. The occipital region of this species closely resembles specimens assigned to the two known species of the Alcoota LF genus *Ilbandornis*.

Genus *Dromornis* Owen 1872

Dromornis stirtoni Rich 1979

Referred material: Cranial bases missing basitemporal plate and basipterygoid processes P98105, P9342; occipitals P98106, P98111; upper beak, P9245; mandibles, P98107, P98112; left pterygoid, P98114.

Locality: Alcoota Homestead, Northern Territory, Australia.

Lithic unit and age: Waite Formation; late Miocene.

Fauna: Alcoota Local Fauna.

Description:

Cranium. The largest of the cranial fragments, P98105, slightly exceeds that of *Bullockornis planei* (P9464–106) in overall size (Fig. 14A–B). P9342 is approximately the same size as the latter specimen. Allowing for individual variability, what is known of the cranial morphology of *Dromornis stirtoni* appears to be very similar to that of *Bullockornis planei*. Both *Dromornis stirtoni* specimens are coronal sections preserving the backs of the orbits, fronto-rostral joint, margins of the basipterygoid and anterior surfaces of the opisthotics. The posterior surfaces are sheared off at about the level of the parietals. The occipital condyle of P98105 was impacted into the posterior surface. As in *Bullockornis planei* the orbital plates are shallow, with large marginal foramina. The postorbital processes of P98105 are longer and narrower than in any *Bullockornis planei* specimen, but those of P9342 are very similar (i.e. short and broad) to the largest Bullock Creek species.

Rostrum. The upper beak of *Dromornis stirtoni* (P9245) is represented by a 200 mm long by 140 mm deep and 60 mm wide fragment that preserves the profile of the beak and its basic form up to an unknown distance anterior to the external nares (Fig. 15A–C). As in *Bullockornis*, the beak

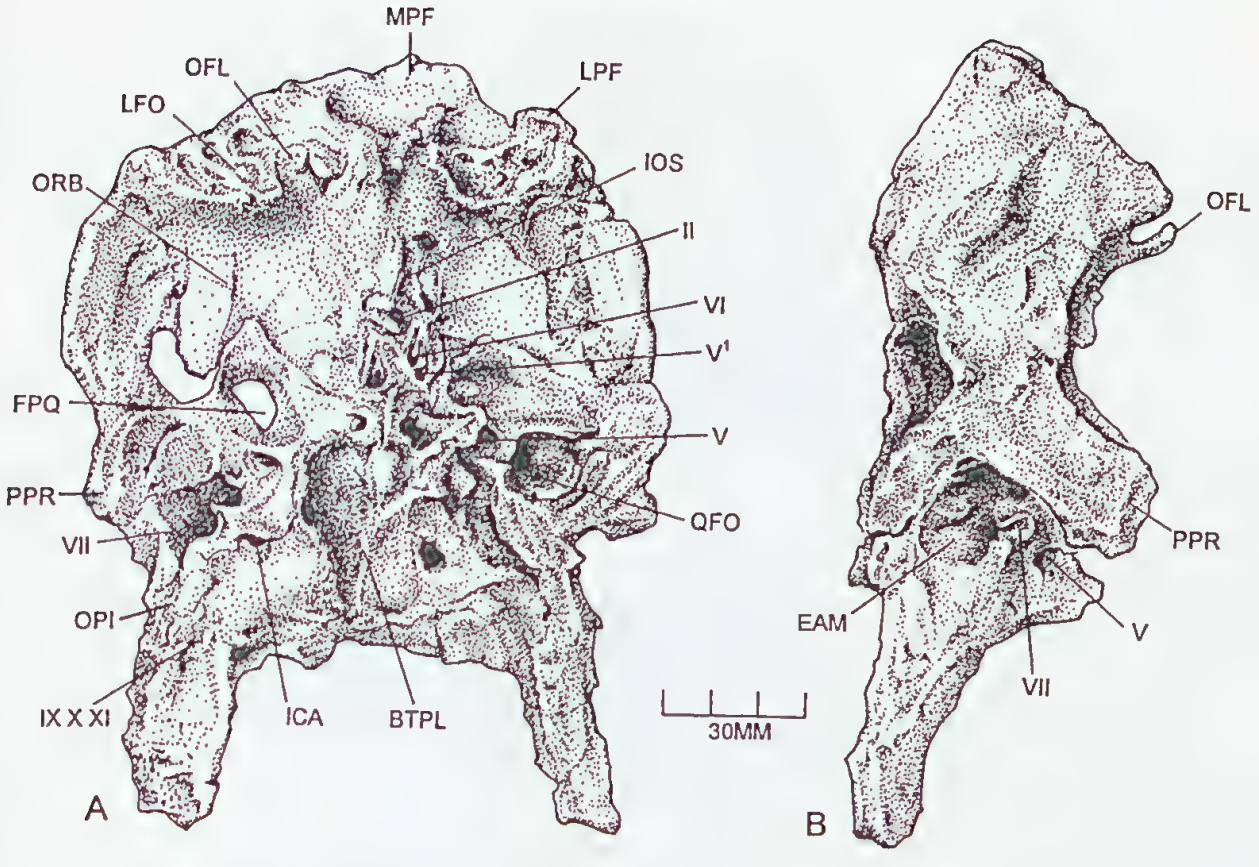


FIGURE 14. Fragmentary cranium of *Dromornis stirtoni* (P98105); **A**, anterior aspect; **B**, lateral aspect. Abbreviations: BTPL, basipterygoid plate (basipterygoid+basioccipital); EAM, external auditory meatus; FPQ, fossa for *mm. protractor quadratus+pterygoideus*; ICA, foramen for internal carotid artery; II, optic nerve foramen; IOS, interorbital septum; IX X XI, accessory, vagus and glossopharyngeal nerve; LFO, lateral fossa or sinus of the frontal; LPF, lateral processof the frontal; MPF, median process of the frontal; OFL, orbital flange; OPI, opisthotic; ORB, orbit; PPR, postorbital process; QFO, quadrate fossa; V, trigeminal nerve; V^1, ophthalmic nerve; VI, abducens nerve; VII, facial nerve.

is deep, narrow and aquiline, with a slightly hooked tip. In ventral aspect, the palate is elongated and narrow with a shallow, solid surface. The median palatal fossa is expressed as a distinct oval depression in the posterior end of the fragment. Posteriorly, the maxillopalatines are fused and form a median process, on either side of which are deep notches possibly representing the anterior borders of the internal nares. The palatines are broad distally, though apparently not as expanded in this region as in *Bullockornis*. Rhinothecal grooves, similar to those of *Bullockornis planei* are evident, though poorly preserved on the specimen.

Pterygoid. The distal half of a left pterygoid (P98114) preserves part of the basipterygoid facet and a nearly complete palatine articular condyle (Fig. 10E,F). The shaft is relatively more slender and triangular in section than that of *Bullockornis*. The basipterygoid facets are situated at the distal end of the shaft and, though the medial half of the facet is missing, it is evident that they were offset to the medial side. These were oval, 29 mm long by an estimated 18 mm wide with a flat surface. The palatine articular surface is 28 mm long by 12 mm wide. A triangular break on the dorsolateral surface may have represented a small process. The preserved surface indicates a simple transverse condylar joint, unfused to the palatine, but with limited movement. A deep, oval fossa for the *m. protractor pterygoideus* is present on the dorsal surface proximal to the basipterygoid facet. The proximal (quadrate) articular surface missing. Based on the complete pterygoid of *Ilbandornis*, the *Dromornis* pterygoid was probably 60–65 mm long.

Mandible. The mandibles of *Dromornis stirtoni* are up to 460 mm long and 140 mm deep at the surangular apex (Figs. 16A–C, 17, 18A,B). In addition to their slightly larger size, the mandibles

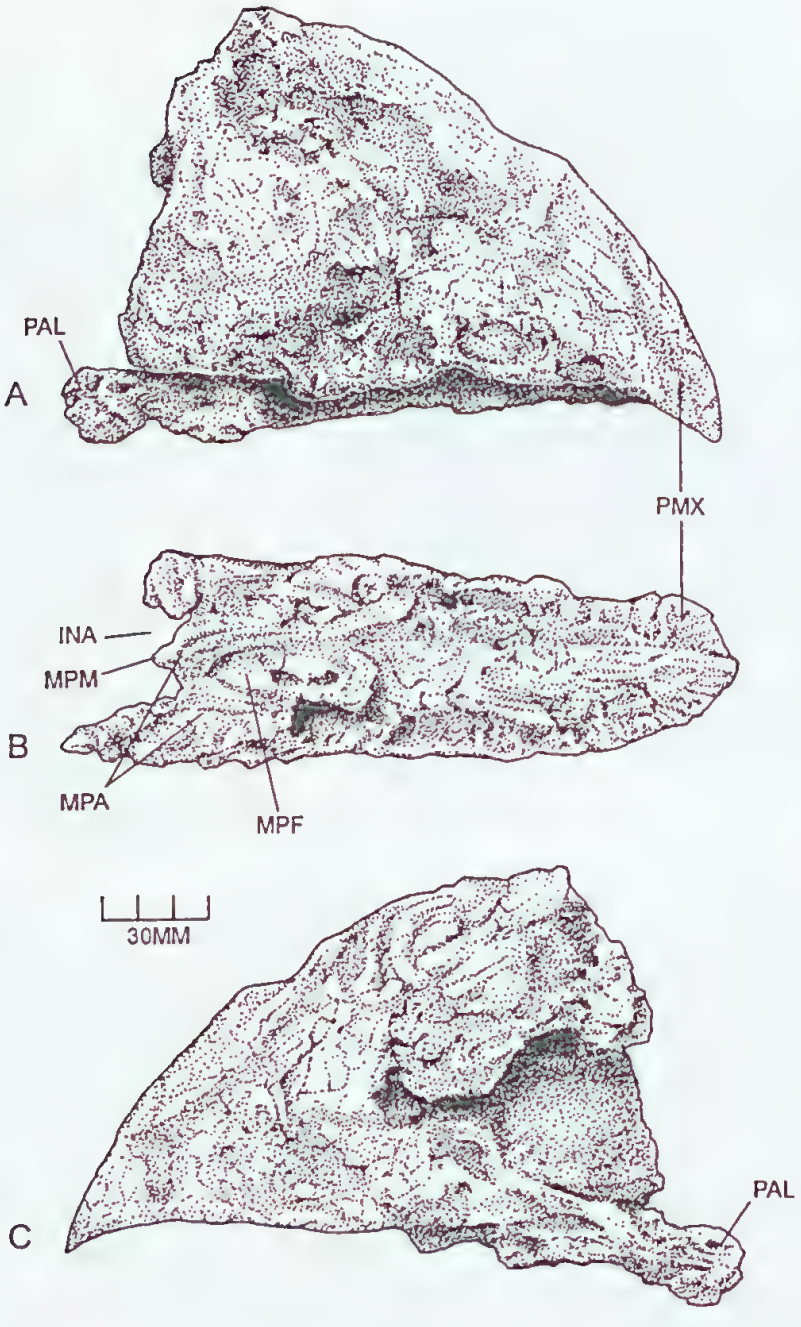


FIGURE 15. Upper beak fragment of *Dromornis stirtoni* (P9245); **A**, right lateral aspect; **B**, palatal aspect; **C**, left lateral aspect. Abbreviations: INA, internal nares; MPA, maxillopalatine; MPF, median palatal fossa; MPM, median palatal process; PAL, palatine; PMX, premaxilla;

differ from those of *Bullockornis planei* in other minor respects. While the mandibles of *Dromornis* are generally very similar to those of *Bullockornis planei*, they are slightly deeper relative to their length, more gracile and appear to have a transversely thinner postarticular process. There is no indication of the coronoid on any specimen and the gonial eminence is broader and less pronounced. Also apparent is a more rounded than angular turn of the dentary at ventral margin of the symphysis. As in *Bullockornis*, the symphysis is fused, but appears to have been shorter. Several *Bullockornis* fragments are not inferior in size to the largest specimens of *Dromornis stirtoni*. The description of the *Bullockornis* mandibles otherwise applies to those of *Dromornis*.

P98107 (Fig. 17) is the only dromornithid mandible in which any part the retroarticular salient is preserved. Judging from the shape of the

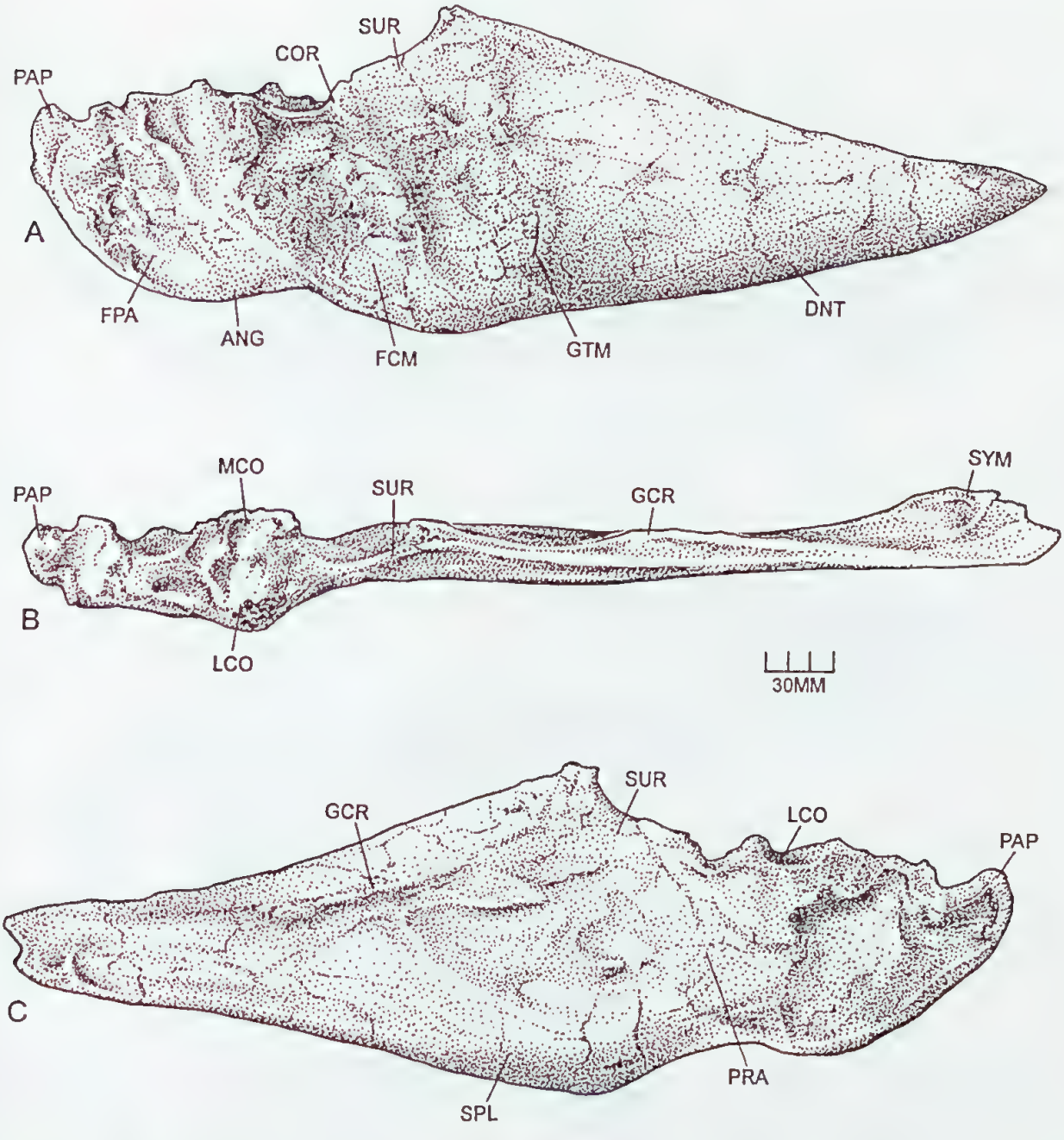


FIGURE 16. Right hemimandible of *Dromornis stirtoni* (P98107) **A**, lateral aspect; **B** dorsal aspect; **C**, internal aspect. Abbreviations: ANG, angular; COR, coronoid; DNT, dentary; FCM, fossa for external adductors; FPA, fossa for *m. pterygoideus* anterior; GCR, gnathothecal crest; GTM, posterior gnathothecal margin; ICC, intercotylar crest; LCO, lateral cotyla; MCO, medial cotyla; PAP, postarticular; PRA, prearticular; SPL, splenial; SUR, surangular; SYM, symphysis.

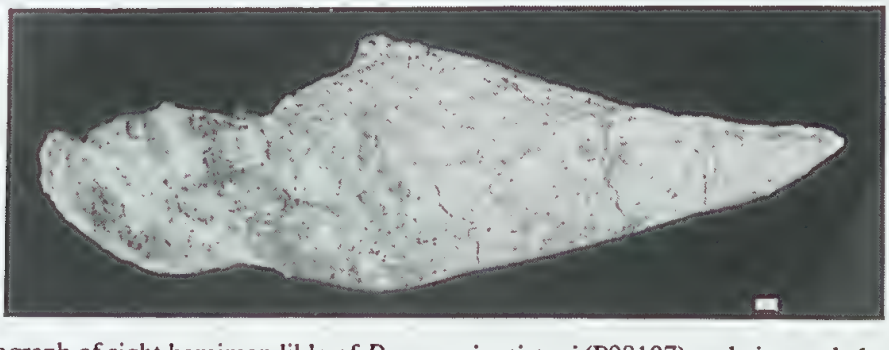


FIGURE 17. Photograph of right hemimandible of *Dromornis stirtoni* (P98107) scale interval=1cm.

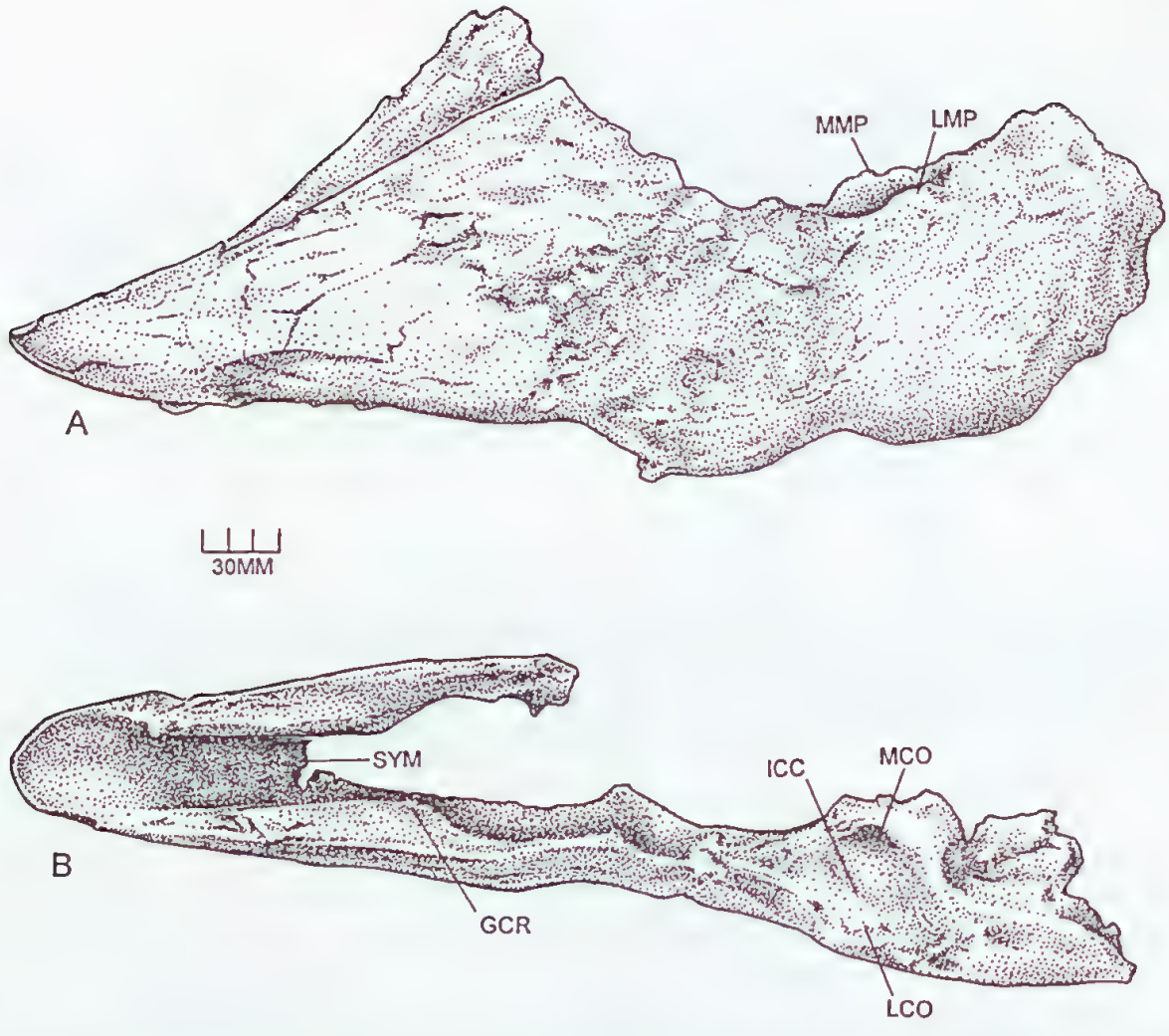


FIGURE 18. Fused hemimandibles of *Dromornis stirtoni* (P98112) **A**, lateral aspect; **B**, dorsal aspect. Abbreviations: GCR, gnathothecal crest; ICC, intercotylar crest; LCO, lateral cotyla; LMP, lateral mandibular process; MCO, medial cotyla; MMP, medial mandibular process; SYM, symphysis.

break, at least half of the distal end (~20 mm) is missing. Projected outlines indicate a crescent-shape structure with the pointed tip, recurved and directed dorsally or slightly anterodorsally. Though mediolaterally compressed (~10–12 mm thick in mid-region), the retromandibular process is very deep dorsoventrally, and rather than being a simple blade-like structure, the internal surface of the entire eminence is emarginated by low crests. As in *Bullockornis*, a shallow fossa is present in the area of the conical recess, as the inferior buttress or crest of the medial mandibular process is comparatively weak.

Genus *Ilbandornis* Rich 1979

Ilbandornis spp.

Referred material: Fragment of cranium, P9843; occipitals, P98108, mandibles, P98109, P98111; left quadrate fragment, P98116; left pterygoid, P98115.

Locality: Alcoota Homestead, Northern Territory, Australia.

Lithic unit and age: Waite Formation, late Miocene.

Fauna: Alcoota Local Fauna.

Description:

Cranium. The cranium of *Ilbandornis* sp. is 30–40% larger than the equivalent part of an Ostrich (Figs 19A–C, 21A). While comparable parts of the cranium are very similar to *Bullockornis* and *Dromornis*, the occipital condyle is relatively small: 11.5 deep by 13.5 wide and distinctly

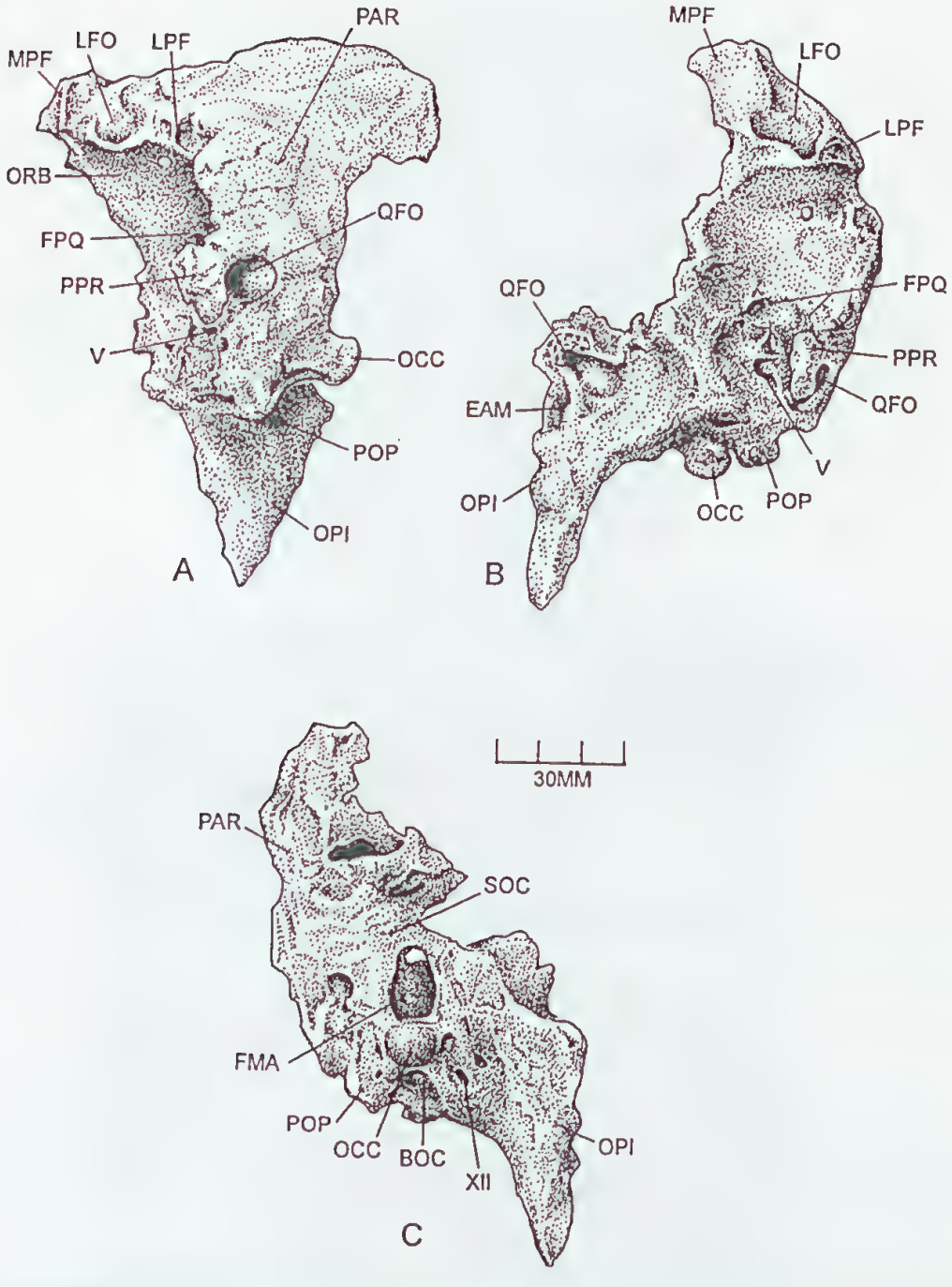


FIGURE 19. Cranial fragment of *Ilbandornis* sp. (P9843) **A**, lateral aspect; **B**, anterior aspect; **C**, posterior aspect. Abbreviations: BOC, basioccipital; EAM, external auditory meatus; FMA, foramen magnum; FPQ, fossa for *m. protractor quadratus+pterygoideus*; LFO, lateral fossa or sinus of frontal; LPF, lateral process of frontal; MPF, median process of frontal; OCC, occipital condyle; OPI, opisthotic; ORB, orbit; PAR, parietal; POP, paroccipital process; PPR, postorbital process; QFO; quadrate fossa; SOC, supraoccipital; V, trigeminal nerve foramen; XII, hypoglossal nerve foramen (condylar).

flattened dorsally. A circular pit is present anteroventral to the base of the occipital condyle. The foramen magnum is oval (19.0 mm x 11.5 mm). The back of the cranium was about 87 mm wide across the post-tympanic crests at the level of the occipital condyle and approximately 145 mm high from the tip of the opisthotic to the top of the cranium. The orbit, as in other species of dromornithid, is shallow and C-shaped, terminating anterodorsally in a low frontal tuberosity. Medial to the tuberosity is the characteristic lateral fossa. The cranial surface above the orbit and the ethmofrontal area is relatively deeper than in other species of dromornithid. The opisthotics are wide, ventrally elongated and greatly expanded posteriorly into a

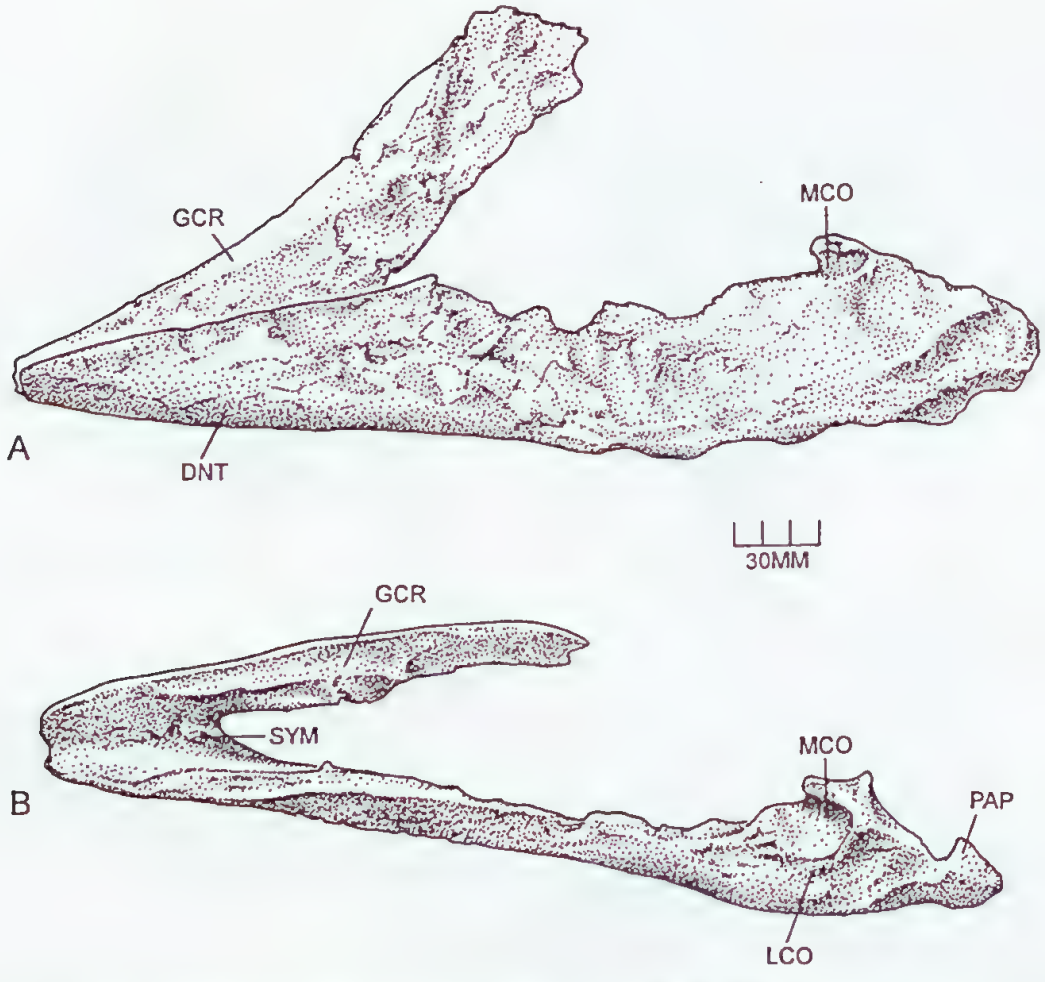


FIGURE 20. Fused hemimandibles of *Ilbandornis* sp. (P98109); **A**, lateral aspect; **B**, dorsal aspect. Abbreviations: DNT, dentary; GCR, gnathothecal crest; LCO, lateral cotyla; MCO, medial cotyla; PAP, postarticular; SYM, symphysis.

sharp, wing-like post-tympanic crests. The neurocranio-mandibular process is laterally compressed and pointed. The quadrate fossae are oval sockets, about 10 mm by 12 mm. The postorbital process is about 20 mm long and 12 mm wide. The basitemporal plate is a pyramidal elevation broken immediately below the parasphenoidal rostrum. The shape of the upper beak is unknown for this species.

Quadrate. A proximal fragment of a left quadrate (P98116), about 15% smaller, but similar to that of *Bullockornis*, probably represents one of the two *Ilbandornis* species. The proximal articular surface of this quadrate specimen is broader and more rectangular than oval in dorsal aspect. There is a faint intercondylar incisure and the pro-otic condyle is slightly broader than the squamosal condyle. The posterointernal surface is damaged in the area of the foramen. An anterolateral crest is present, which appears to have been shorter, though as prominent as in *Bullockornis*. In the *Ilbandornis* specimen, an oval fossa is present in about the same position as the ligamentous groove along the margin of the lateral crest in *Bullockornis*. The orbital process is incomplete.

Pterygoid. The pterygoid (P98115) is fairly short (51.5 mm) and straight, retaining a simple, 17.5 mm by 12.5 mm transverse condylar joint with the palatine distally and a deep, oval (11 mm x 8 mm) articular socket for the quadrate proximally (Fig. 10G–I). The 20 mm by (estimated) 15 mm basipterygoid facet is incomplete, but appears to have been oval and flat. As in other dromornithids, the facets are situated near the distal end and offset to the dorsomedial side of the shaft. A deep fossa for the *m. protractor pterygoideus* is present on the posteroventral surface which is penetrated by two small foramina. Dorsally, a low, longitudinal crest extended over most of the length of the shaft. Much of the ventromedial surface is eroded, which includes the ventral crest, the ventral half of the

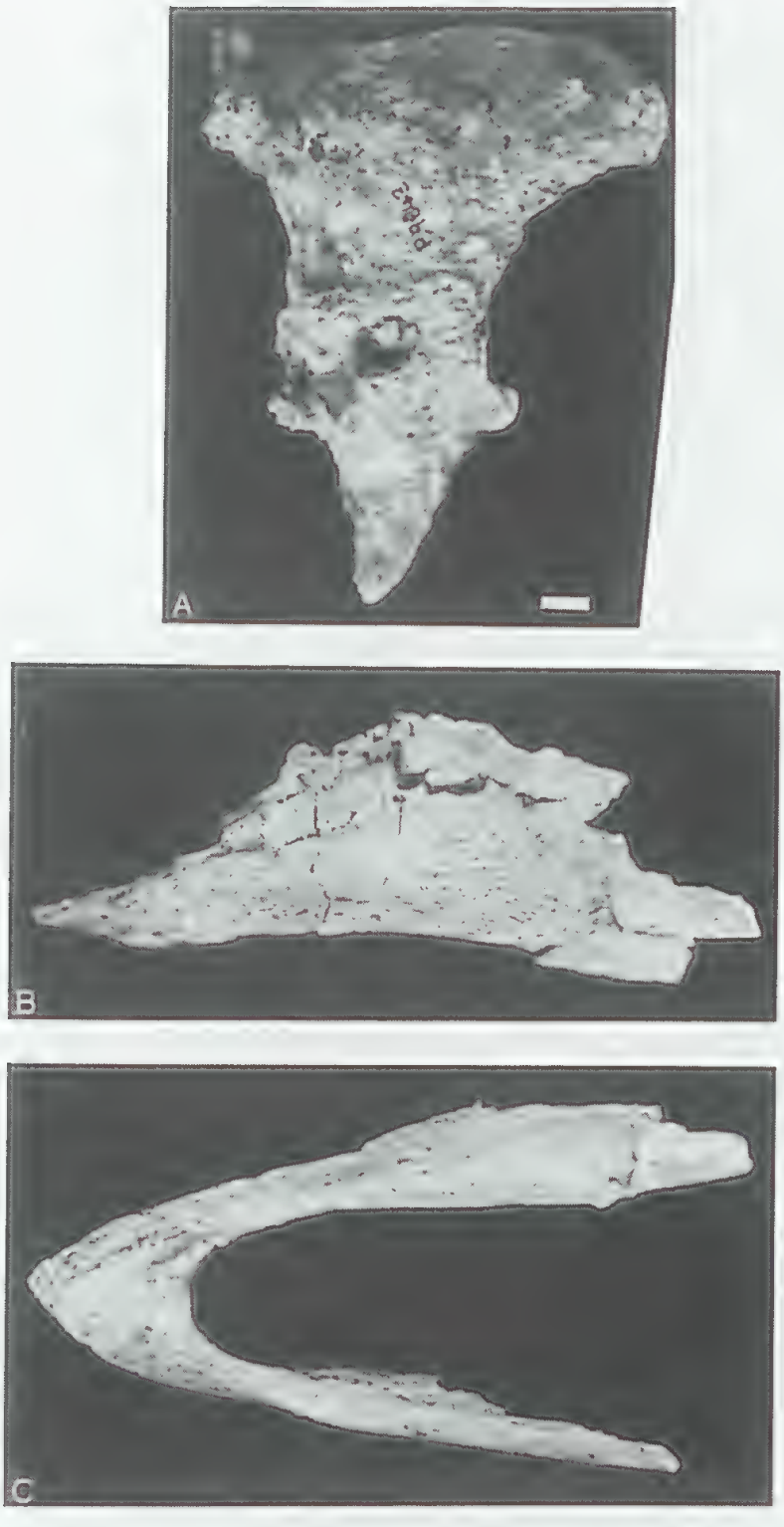


FIGURE 21. Photographs of: **A**, left side of cranial fragment of *Ilbandornis* sp. (P9843) note laterally compressed, dagger-like neurocranio-mandibular process; **B**, left side of mandible fragment of *Ilbandornis* sp. (P98111), distinguished from mandible P98109 by concave ventral border, small size, deeper dentary, wide symphysial notch, **C**, ventral aspect of mandible fragment of *Ilbandornis* sp. (P98111).

basipterygoid facet and the ventromedial process of the pterygopalatine articular surface.

Mandible. The most complete mandible of *Ilbandornis* is shallower in relation to its length than in *Bullockornis* and *Dromornis*, though otherwise similarly constructed. P98109 is 380 mm long and about 70 mm deep at the distal end of the dentary margin. The tomial profile is slightly concave; decurved at the tip (Fig. 20A,B). The ventral margin is straight. As in other dromornithid species, the symphysis of the two

hemimandibles is fused. The most obvious differentiating features of this specimen is the suppression of its gonial angle and slenderness of the horizontal rami.

A second, much smaller specimen of *Ilbandornis* (P98111) is distinguished by its concave ventral profile commencing anterior to the gonial expansion (Fig. 21B–C). A section of the tomial margin is present, the angle of which suggests that the mandible was significantly deeper relative to its length than P98109. As indicated by the postcranial skeleton, the two species of *Ilbandornis* are quite different, but to which species the mandibles or the cranial fragment might belong has not been confirmed by association.

Observations on *Genyornis*

Though the skull of *Genyornis newtoni* is poorly preserved, it makes an important contribution to dromornithid morphology in showing proportions that must otherwise be inferred from isolated and fragmentary elements. Conversely, the new dromornithid material elucidates some structural elements of *Genyornis* previously overlooked or considered too fragmentary to interpret. As the actual skull of *Genyornis newtoni* was unavailable for study[1], we have relied on the photographic plates and descriptions of Stirling and Zietz (1913).

The preserved neurocranial and orbital elements closely resemble those of better preserved dromornithid specimens (Stirling and Zietz 1913 pl. XXXVI, Fig. 1). Of particular interest are the relationships at the cranio-rostral contact. While this area is partially obscured by plaster, *Genyornis* appears to have a well-developed transverse cranio-rostral joint indicated by a shallow V-shaped notch in the dorsal profile. The culmen is strongly arched as in *Bullockornis*, except that the anterior limb of the arch descends steeply towards the tip of the beak.

The descending process of the lachrymal is probably indicated by a raised area of oriented fragments. The dorsal part of the lachrymal extends a lobe anteriorly defining the posterior side of the anteorbital fenestra. The anteorbital fenestra appears to have been a triangular slot, anterior to which, a fan-shaped mass descends obliquely towards the ventral margin, representing the anteroinferior process of the nasal bone. A hollow region immediately anterior to the descending process of the nasal suggests a large, oval external narial aperture. The posterior margin of the maxilla is partially intact. It appears to have been deep, and obviously made contact with the anterior process of the nasal bone.

The back of the cranium is badly damaged, the only visible structure being the quadrate fossa, the right post-tympanic crest having been crushed forward, obscuring the auditory meatus. Stirling and Zietz (1913) placed the quadratojugal in the position shown in the photograph. An oval structure lying under the quadratojugal could be an articular facet of the basipterygoid process which would occur in about that position. Having examined the photograph carefully under magnification, it clearly represents bone, with some open trabeculae around the anterior edge. This appears to be the structure Stirling and Zietz (1913) refer to as '...part of the articular surface for the quadrate...'. Stirling and Zietz were convinced that extreme lateral crushing of the specimen had distorted the proportions of the beak beyond usefulness, but as it is now known that the beak in dromornithids is laterally compressed, the shape is probably fairly representative for the species.

Assuming that the fossil retains a reasonably accurate indication of the original shape of the skull, *Genyornis newtoni* seems to bear a closer superficial resemblance to a goose (*Anser*) or a screamer (*Chauna*) than it does to any ratite species. Overall proportions are goose-like: in the goose, orbital length is 21% of the total length, which is 17% in *Genyornis*. The beak is 50% of the cranial length in the goose, as it is in *Genyornis*, and the depth of the cranium in the goose is about a third of its length, the same, as near as we can estimate, as in *Genyornis*. In addition to its *Anser*-like proportions, the outline of the beak and dorsal surface of the cranium of *Genyornis* are strongly reminiscent of a screamer, such as *Chauna torquata* (Anhimidae); the culmen being aquiline and the inferior margin of the mandible being slightly concave. The reconstruction of the skull of *Genyornis* in Rich

[1] Neville Pledge, Curator of Fossils, South Australian Museum informed us that the skull of *Genyornis newtoni* is '...too fragile in its present state to travel,' adding: 'When it was found originally, exposed in the surface weathering zone, apparently it was recognised as a skull but too fragmentary to collect in the rather primitive way the diprotodons were being dug up. Instead they (whoever they were) poured liquid plaster over the surface, embedding the bone fragments where they were. Enough must have percolated through to the bottom to hold the unexposed side in place when the block was excavated and turned over. I do not believe any reconstruction was done to the shape or proportions of the skull by Stirling and Zietz.'

(1979, Fig. 1) is based on emu morphology, at the time a reasonable but misleading assumption, showing a large confluent anteorbital-narial aperture with horizontal premaxillary and maxillary plates, emu-like prefrontal and postorbital with a well-defined temporal fossa bounded by postorbital and zygomatic processes.

Stirling and Zietz (1913) concluded that the quadrate of *Genyornis newtoni* '...differs very considerably from that of existing ratite birds...', though in spite of this explicit observation to the contrary, Matthew and Granger (1917) state that the quadrate of *Genyornis* '...is typically dromaeognathine'. While Stirling and Zietz's (1913) figures of the quadrate generally correspond to that of *Bullockornis planei*, there are some significant proportional differences. The quadrate of *Genyornis* is less robust, with a narrower body and much narrower condyles for the articular.

The articular facet for the qudratojugal is situated lower relative to the external articular condyle than in *Bullockornis* but 'sessile' rather than stalk-like as in ratites. Unlike *Bullockornis*, the head is small and composed of a single, undivided hemispherical surface (Stirling and Zietz 1913). A strong crest extends down the anterolateral surface of the otic process for the *m. adductor mandibularis externus* and the pterygoid articulation is a small oval tuberosity, unlike the large, concave, elongated pterygoid facets in the Emu and Ostrich.

Stirling and Zietz (1913) apparently confined their comparison of *Genyornis*'s quadrate to ratites alone, for had they examined the quadrates of a domestic chicken, megapode or duck, surely the more familiar ground would have been recognised. Stirling and Zietz (1913) isolated the very suite of characters that indicate that the quadrates of *Genyornis* were mobile, like those of neognathous birds, but failed to appreciate the significance of the morphological complex in relation to dromornithid systematics.

Comparative morphology

The long systematic association of dromornithids with ratite birds necessitates a

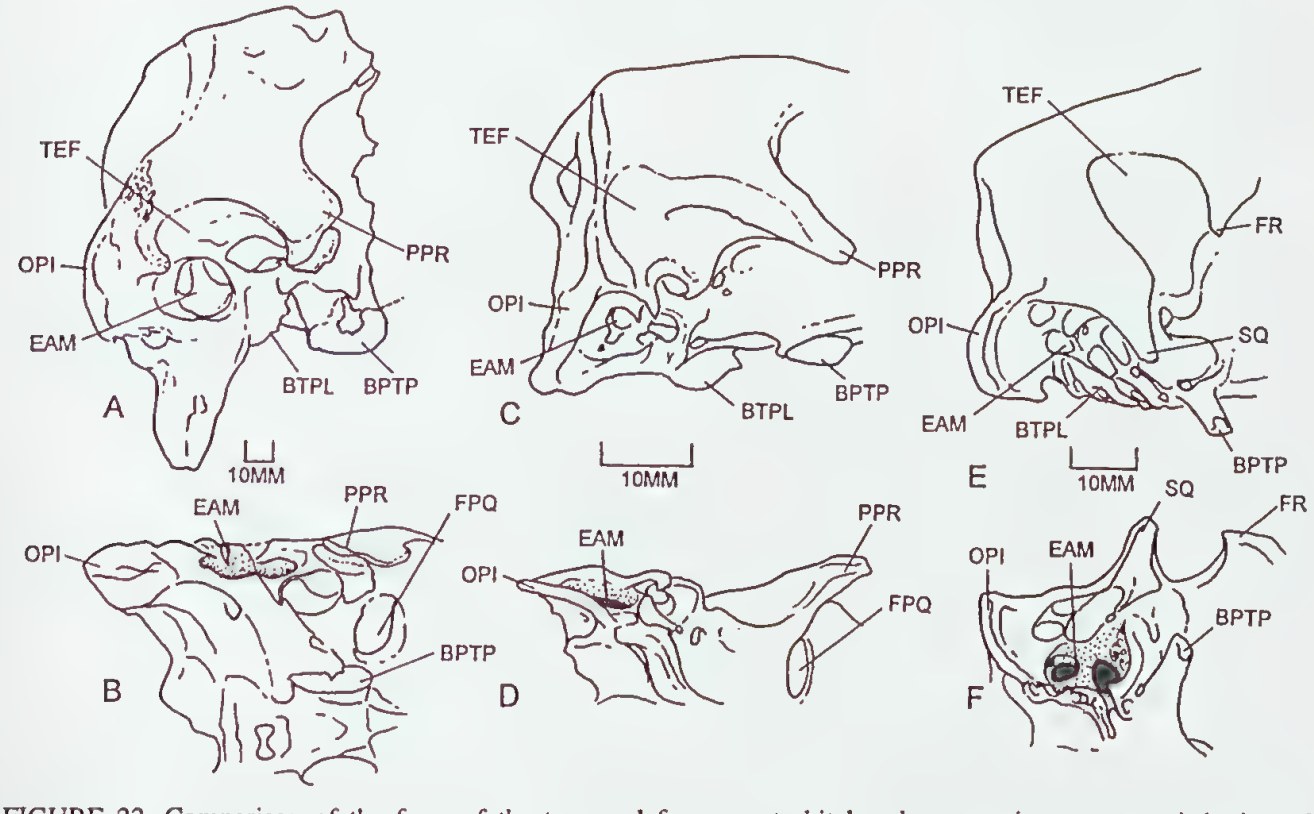


FIGURE 22. Comparison of the form of the temporal fossa, postorbital and zygomatic process, opisthotic and external auditory meatus in **A** & **B**, *Bullockornis planei*; **C** & **D**, *Anas* sp. (domestic duck); **E** & **F**, *Dromaius novaehollandiae* (Emu). In the Emu, squamosal (SQ)=zygomatic process and frontal (FR)=postorbital process; BPTP, basipterygoid process; BTPL, basipterygoid plate; EAM, external auditory meatus; FPQ, fossa for *m. protractor et levator quadratus+pterygoideus*; FR, frontal; OPI, opisthotic; PPR, postorbital process; SQ, squamosal; TEF, temporal fossa.

comparison with the dromaeognathous species. While examples from a variety of living neognathous orders were examined, the majority of our observations pertain to anseriform and galliform species. The Ostrich and Emu are the principle palaeognathous forms used for comparison. Dromornithid features of particular interest in this study are the form and structural relations of the cranial vault; the cranio-rostral surfaces; the zygomatic process and temporal fossa; the basipterygoid-parasphenoid complex; the quadrate and pterygoid and the upper beak.

Cranium. The dermal elements of the dromornithid cranium are exceptionally short, compared to galliform and ratite birds. The frontal is retracted and broad, somewhat like that of a parrot. The narrow crescents of the parietals appear to be mostly confined to the posterior surface of the cranium, extending a short distance onto the lateral surface above the squamosal at the level of the quadrate fossa. In the Emu, Ostrich and Rhea, the parietals are broad and extend to the laterosphenoid below the postorbital process of the frontal. An interparietal-like structure is outlined above the supraoccipital in *Bullockornis*. Heilmann (1926) depicted an interparietal in the gosling, but we were unable to confirm its presence in a younger domestic gosling specimen. It appears to be present in a young Magpie goose, although the suture could represent an overlap of the parietal onto the supraoccipital. A distinct interparietal bone is absent in the chicks of Ostrich, Emu, Domestic fowl and megapode.

The form of the opisthotics is highly distinctive in dromornithids (Fig. 22A, B). The rounded post-tympanic crest of the opisthotic is thick and greatly expanded in the parasagittal plane, terminating in a long, slender ventrally-directed process extending from immediately below the external auditory fenestra. The auditory fenestra is situated within a laterally directed cavity formed by the anterior and posterior crests of the opisthotic. The ventral crest of the opisthotic is well-developed, obscuring the auditory fenestra from view in the ventral aspect. Posterodorsal to the auditory fenestra, a thick crest for the adductor aponeurosis defines the posterior margin of the temporal fossa which continues anteriorly to below the base of the postorbital process in the form of a circular fossa.

The morphology of this region differs markedly from that of ratite birds (Fig. 22E, F) in which the crest of the opisthotic forms a cup-shaped arch over the auditory fenestra, while in ventral aspect, the auditory fenestra is quite visible, as the crest terminates posterior to its orifice as a transversely directed flange. In anseriform birds (Fig. 22C,D) the post-tympanic crest is oriented in the parasagittal plane and the ventral crest and tympanic ring encloses the laterally open auditory recess, as in dromornithids. The crest is also more ventrally-directed and elongated than in ratite birds, usually terminating ventrally in a slender, conical process. In galliform birds, the post-tympanic crest is weak and oriented transversely as in the majority of neornithians.

The structure of the postorbital and temporal fossa region of the dromornithid cranium differs markedly from that of the Emu and Ostrich (Figs. 22E,F, 23F–H). In dromornithids the postorbital process is a composite structure consisting of the postorbital lamina of the squamosal and possibly the frontal externally, which fuses with an internal process of the squamosal and pterosphenoid that may be homologous with the zygomatic process. Consequently, the temporal fossa is displaced posteroinferiorly, behind and below the squamosal. In all ratite birds, a large and well-defined temporal fossa is formed between the squamosal (zygomatic process) and the postorbital (frontal) processes (Fig. 23F–I). In many galliform birds (also parrots, frogmouths and diatrymatids) the two processes, which are composed in the former of the squamosal and laterosphenoid dorsally (postorbital process) and the squamosal ventrally (squamosal process), form an arcade around the adductor muscles, recreating a temporal fenestra (Heilmann 1926), (Fig. 23C, I); whereas the two processes (postorbital process of the frontal and squamosal process) remain widely separated in the Ostrich and Emu (Fig. 23F–H). The condition in anseriform birds is like that of dromornithids in that the temporal fossa is situated posteroventral to the postorbital process, which is composed primarily of the squamosal externally and the laterosphenoid internally, though its individual components are not evident in adult birds (Fig. 23D, E).

Cranio-rostral joint. The anterior orbital region, consisting of the posterior processes of the nasals, the lachrymals and posterodorsal premaxillary process is not known. The frontal hinge is composed of a median eminence with a large fossa on either side, floored by a hinge-like process of the orbital roof (orbital flange), that probably articulated with the posterior process of the nasal and perhaps the base of the lachrymal. Below the frontal eminence is a shallow, smooth-

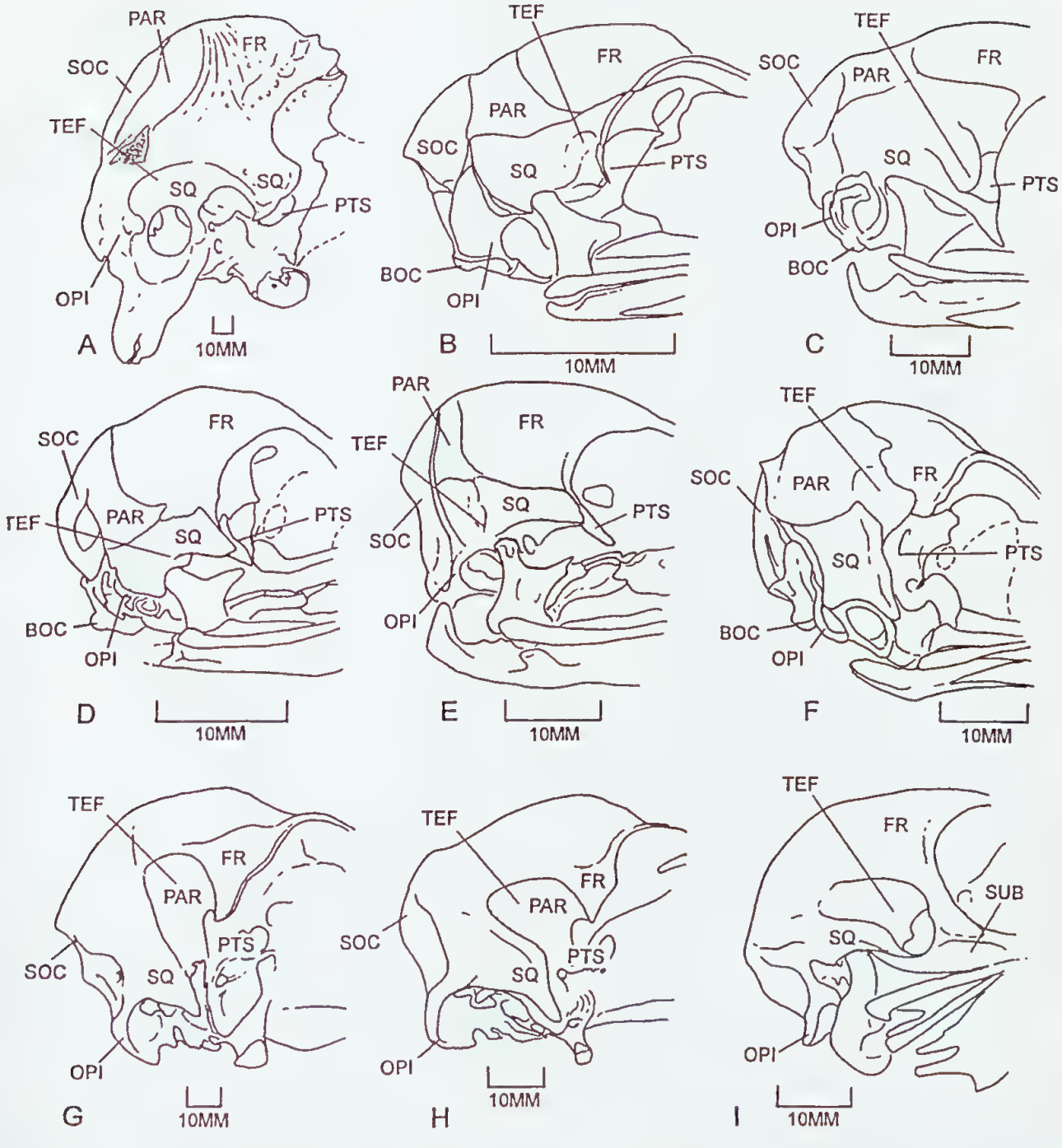


FIGURE 23. Comparison of structure of the cranial sidewall in **A**, *Bullockornis planei*; **B**, Domestic chick, *Gallus gallus*; **C**, adult Domestic chicken, *Gallus gallus*; **D**, domestic gosling, *Anser* sp.; **E**, Pink-eared duck, *Malacorhynchus membranaceous*; **F**, 6-week old Ostrich chick, *Struthio camelus*; **G**, adult Ostrich, *Struthio camelus*; **H**, adult Emu, *Dromaius novaehollandiae*; **I**, cockatoo, *Cacatua* sp. Abbreviations: BOC, basioccipital; FR, frontal; OPI, opisthotic; PAR, parietal; PTS, pterosphenoid; SOC, supraoccipital; SQ, squamosal; SUB, suborbital; TEF, temporal fossa.

surfaced transverse groove denoting the dorsal surface of the mesethmoid and possibly represents the contact with the posterior process of the premaxilla.

Regardless of the specific configuration of the contacts, of which several plausible alternative interpretations can be made, the structure shows similarities with the mobile joint surfaces on the posterior margin of the upper beak of anseriform birds and to some extent also parallels the condition in parrots. Parrots, because of their broad, shortened anteorbital region and deep posterior surface of the beak, present a broad, rectangular cranio-rostral interface with distinct

median frontal and mesethmoidal eminences bordered by fossae on either side. A naso-premaxillary hinge traverses the entire dorsal margin of the joint, the topographical equivalent of which in dromornithids is a rugose, upturned transverse crest. In ducks and geese, the two lateral fossae form hinge-and-socket joints between the anterodorsal prefrontal margin and the descending nasal processes, connected by ligaments. The median part of the hinge is formed by thin, flexible bony processes of the nasal and the premaxilla which are enveloped by an overgrowth of the frontal. The transverse sulcus below the frontal eminence in *Bullockornis* resembles the broken margin of a similarly thin bony lamina.

Ratite crania, which are rhynchokinetic, show no similarities to the distinctive prokinetic dromornithid cranio-rostral morphology. The dorsal lamina of the ethmoid presents an elongated, flattened surface overlain anteriorly by a thin lamination of the posterior process of the premaxilla and is bound-in laterally by the posterior processes of the nasals; whereas in dromornithids, the ethmoid appears to have terminated under the frontal as in parrots, allowing the rostrum to flex to some extent along the joint surface, depending on the nature of its ligamentous attachments (discussed in the following section). Ratites lack a transverse cranio-rostral hinge and the beak is essentially rigid, although varying degrees of rostral kinesis are present in different species depending primarily on the flexibility of the premaxillary arch (Simonetta 1960, Bock 1963).

Rostrum. The upper beak differs substantially in form and structure from those of the Emu and Ostrich. Unlike either of the latter species, the beaks of dromornithids are deep and laterally compressed, with sheer, solid lateral walls apparently composed predominantly of the premaxilla anteriorly and the nasals and maxilla posteriorly. As the only suture visible on the specimens is the maxillo-premaxillary, the precise form and extent of the nasal bone is unknown. The small external narial aperture of *Bullockornis planei* is strikingly similar to that of *Diatryma steini* and *D. gigantea* (Matthew and Granger 1917, Andors 1992).

The beaks of *Dromornis* and *Genyornis* indicate that the maxilla was deep and extended posteroventrally below the jugal process. Consequently, the descending process of the nasal made contact with the maxilla. In dromaeognathous birds, the posterolateral processes of the premaxilla and maxilla are reduced or absent, leaving only the palatal processes, while the descending process of the nasal is closely applied to the premaxilla resulting in a large, confluent anteorbito-narial fenestra (schizorhinous), (Simonetta 1960, Bock 1963). Thus the external surfaces of the beak of dromornithids is clearly unlike those of any living or extinct palaeognath. The structure of the palatal surface of the dromornithid beak also shows an important contrast with paleognaths in its fusion of the maxillopalatines at the mid-line, forming a median process that loosely articulated with the distal end of the prevomer. The vomers were fused into a relatively short, vertical plate that did not contribute a fused ventromedian lamination of the palatal roof as in dromaeognathous ratites. Instead, dromornithids had an extreme form of desmognathous palate.

Cranial base. The morphological details of the basisphenoid differ significantly from the equivalent regions in the Emu and Ostrich. In addition to their nearly conjoined facets, the basipterygoid processes appear to arise a considerable distance distal to the surface of the basitemporal plate as indicated by the position of the eustachian canals and internal carotid (parasphenoidal) foramina. Unlike the Emu and Ostrich in which the eustachian canals are situated laterally at the base of the each basipterygoid process, the eustachian canals in dromornithids are confluent at the mid-line of the basitemporal plate, opening on the posteroventral margin of the basipterygoid rostrum, as typifies neognathous birds (Fig. 24A–H). This complex is related to a subtle difference in the basipterygoid-parasphenoid union. In palaegnathous birds, the basisphenoid contacts the parasphenoid a short distance posterior to the eustachian openings, whereas in neognathous birds, including dromornithids, the basisphenoid sends a thin lamination of bone over the sutural contact, thus enclosing the eustachian canals which initially perforate the basisphenoid in about the same lateral position as in the Ostrich and Emu. In 3-week and 6-week old Ostrich chicks, and presumably adults, the anteromedial ends of the eustachian canals are enclosed by a cartilaginous extension that opens confluently on the mid-line, that is apparently homologous to the bony overgrowth of the basitemporal plate seen in neognaths.

In dromornithids the lateral wings of the body

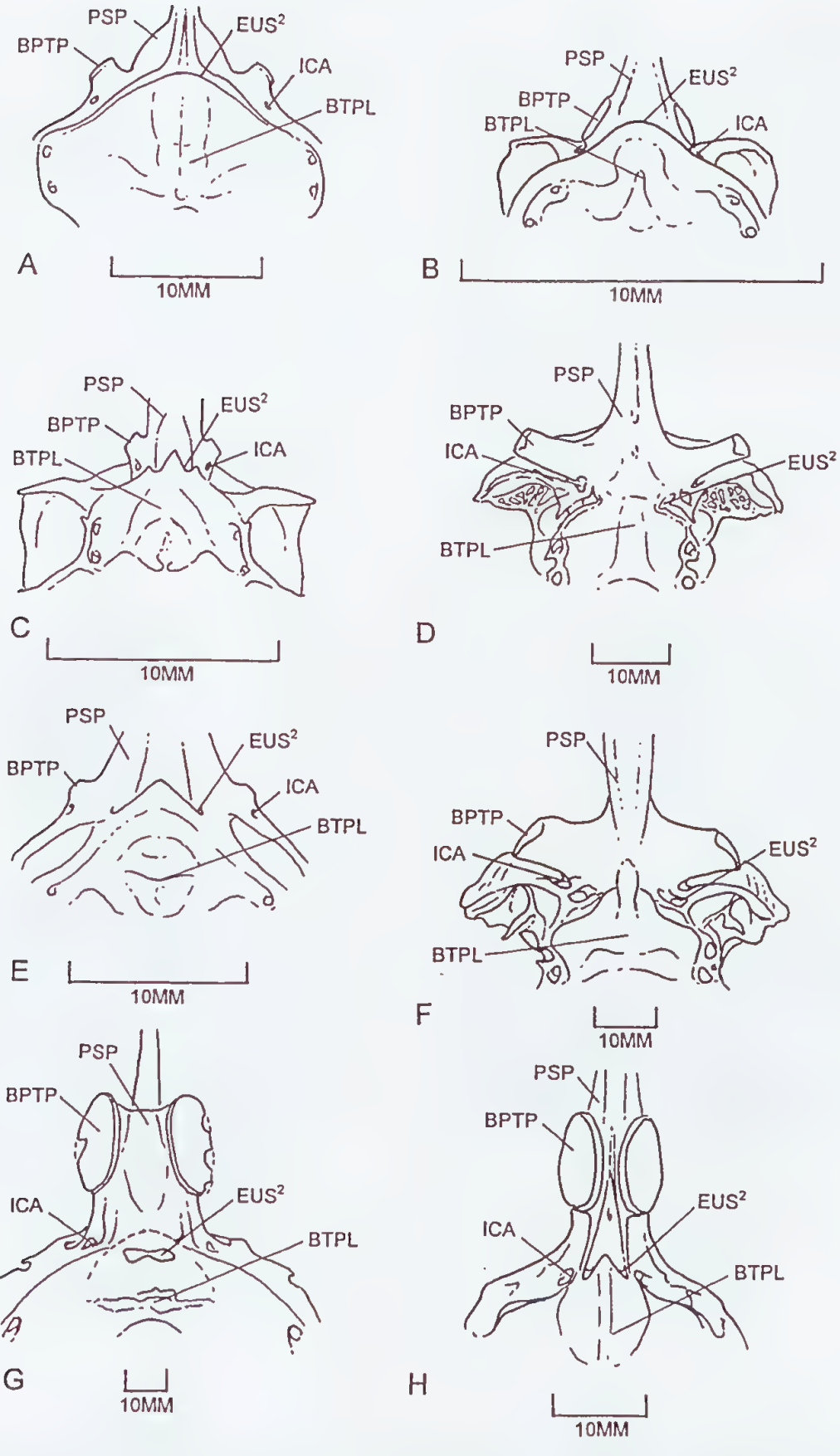


FIGURE 24. Comparison of basipterygoid and rostropterygoid articulations in various palaeognathous and neognathous birds; **A**, Barking owl, *Ninox connivens*; **B**, Button quail, *Turnix velox*; **C**, Partridge pigeon, *Geophaps smithii*; **D**, Emu, *Dromaius novaehollandiae*; **E**, Spotted nightjar, *Eurostopodus argus*; **F**, Ostrich, *Struthio camelus*; **G**, dromornithid, *Bullockornis planei*; **H**, domestic duck, *Anas* sp.

of the basisphenoid (the 'alisphenoid' of Owen) are rounded, sloping surfaces rather than swollen transverse crests forming the anterior wall of the auditory canal in the Emu and Ostrich, nor is there a rugose crest or swelling present along the contact area between the laterosphenoid and the basisphenoid. The equivalent area in *Bullockornis*, *Dromornis* and *Ilbandornis* is occupied by a deep circular fossa for the origin of the protractors quadratus and pterygoideus muscles, very similar to that of many ducks and geese and which are rarely, if ever, as well-developed in other neognathous species (Fig. 22B–D, Fig. 1B). As such, the basic form and relations of the basicranium of dromornithids is a great deal more like those of anseriform birds than to any of the living palaeognaths.

In dromaeognathous ratites the basipterygoid processes arise from the cornua of the basitrabecular cartilage which ossify as laterally-directed stalk-like, tubular outgrowths of the basisphenoid on either side of the base of the parasphenoidal rostrum (Fig. 24D, F). These are present and fully ossified in late embryos of the

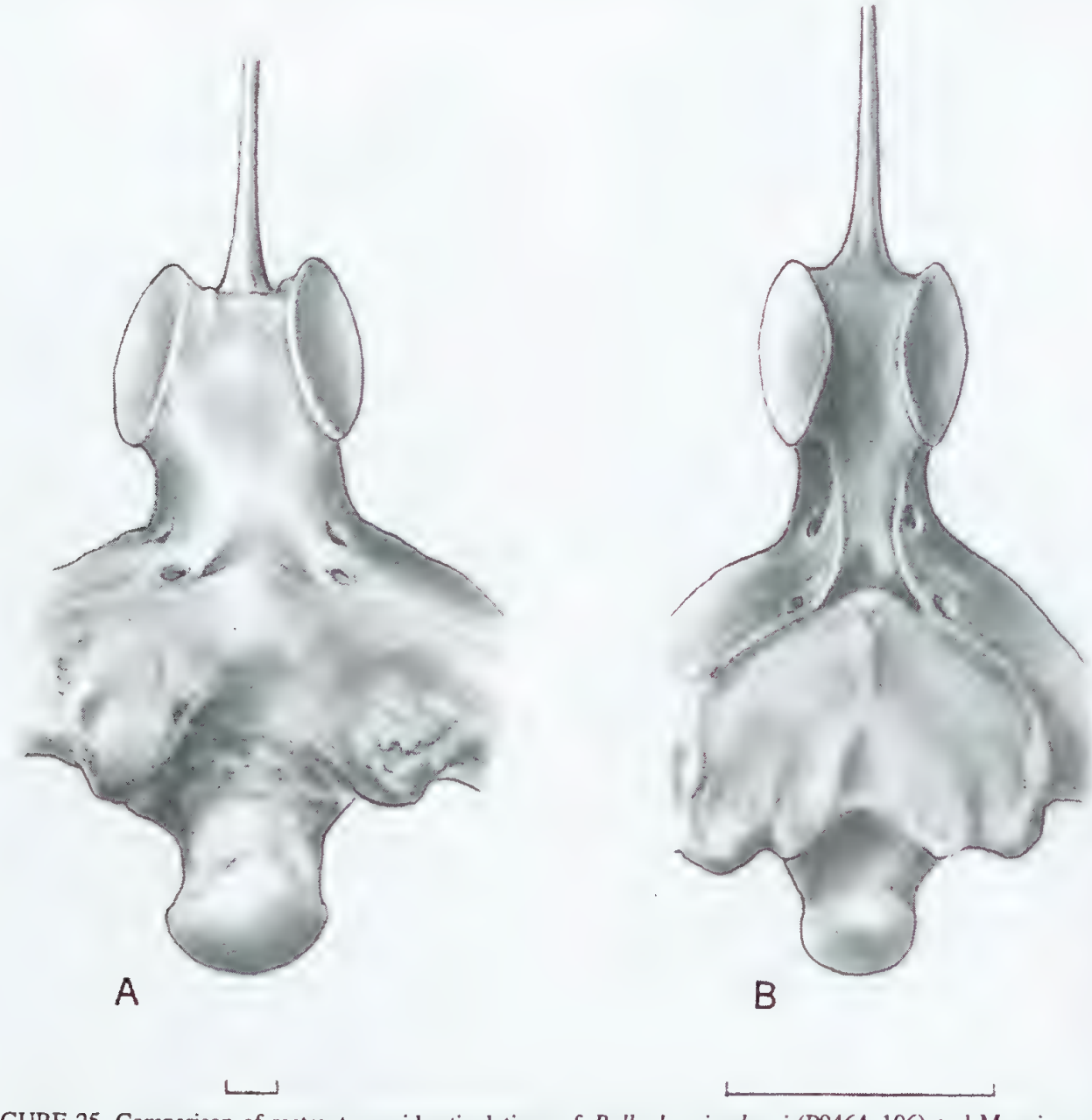


FIGURE 25. Comparison of rostropterygoid articulations of *Bullockornis planei* (P9464–106) and Magpie goose (*Anseranas semipalmata*); **A**, *Bullockornis planei* (chipped margins of facets, margin of eustachian opening and parasphenoidal rostrum partially restored); **B**, Magpie goose (*Anseranas semipalmata*); scale bar=10mm; The rostropterygoid articulations of *Bullockornis* show specific similarities to those of Anseranatidae in that the parasphenoidal rostrum is narrow, the facets are more widely separated than in many other Anseriformes and the interarticular surface of the parasphenoid is flattened.

Ostrich and Emu, whereas the basipterygoid processes of relatively more mature, week-old anseriform and galliform chicks are represented by stalk-less, concave cartilaginous placodes developed over partially ossified bone on the ventral surface of the parasphenoid. The pedicles develop gradually as the birds mature, and appear to arise as an interaction with the contacting surface of the pterygoid. It is likely, therefore, that the basipterygoids (rostropterygoids) of anseriform and galliform birds and by virtue of their close similarity, those of dromornithids, are not strictly homologous with the basipterygoid processes of palaeognathous birds or those of neognathous birds which have true basipterygoid processes (Weber 1993). Some neognathous birds, such as Boobook owls, have both rostropterygoid and basipterygoid processes, indicating that the more anterior (rostropterygoid) facets on the parasphenoid are neomorphic structures.

The position of the facets along the parasphenoid differ in various anseriform species. They are situated closer to the base of the parasphenoid in the Magpie goose and more distally in Black and Pink-eared ducks. The rostropterygoid morphology of *Bullockornis* is very similar to that of a Magpie goose (Anseranatidae), but with the facets directed more ventrally in relation to the parasphenoidal rostrum (Fig. 25A,B). The main difference between dromornithid and anseranatid rostropterygoid morphology appears to be a proportional modification associated with the extreme shortness of the orbito-frontal region, resulting in a steep upward angulation of the parasphenoidal rostrum. The true basipterygoid processes of paleognathous and neognathous birds, while differing in form and length, appear to consistently arise from the same part of the basisphenoid (Fig. 24A–F).

Unfortunately, the interorbital septum and parasphenoidal rostrum are damaged in all dromornithid specimens. The base of the parasphenoidal rostrum is present in P9464–106, indicating that it was narrow and sharply crested on its ventral surface as in *Anseranas*, and angled anterodorsally, hence unlike those of any ratite, though typical of many neognathous birds. Similarly, the mesethmoidal septum appears to have been short and thin, indicating that the rostrum probably did not project beyond the level of the anterior orbital margin.

Quadrate. The quadrates of the Emu and Ostrich closely resemble one another in overall form and in many specific morphological details. The head in both species is elongated and narrow, the quadratojugal tuberosity is a long, stout pedicle with a narrow external articular facet on the ventral surface, widely separated from the internal articular facet by a U-shaped intercondylar fossa. The quadrates of *Bullockornis* have a broad, oval squamosal articular surface, faintly divided into pro-otic and squamosal condyles by a shallow, nearly obsolete intercondylar incisure. The quadratojugal facet is closely applied to the body (Fig. 26A–G) and probably buttressed posteriorly. The external articular condyle was situated close to the internal and divided from it by a shallow groove. The anterolateral crest on the otic process is not present in the Emu and Ostrich. Significantly, the pterygoid articular surfaces in the Emu and Ostrich extend dorsally onto the base of the orbital process to form a wide, essentially immobile joint in contrast to the mobile ball- and-socket joint formed between the quadrate and pterygoid in dromornithids.

The quadrates of anseriform birds are very similar to those of *Bullockornis*, differing in the less distal extent of the anterolateral or otic crest and in possessing (in part) a more distinct intercondylar incisure on the head. It appears that the pro-otic condyle and the squamosal condyle have coalesced or that the pro-otic condyle has been greatly reduced in some dromornithids, especially in *Genyornis newtoni*. While the lateral crest for the *m. adductor mandibulae externus profundus* is well-developed in many species of anseriform birds, it does not extend as far distally in any of the specimens examined in this study, nor is the longitudinal groove on its anterior margin as well-developed or extensive. The quadrate of *Genyornis newtoni* (Stirling and Zietz 1913) is less robust than that of *Bullockornis*; more tapered distally and possesses a more elongated, slender and posteriorly directed otic process. While the *Genyornis* specimens show some proportional differences from those of *Bullockornis*, none of these are in the direction of dromaeognathous ratites.

Pterygoid. Among the three genera of dromornithids for which the pterygoid is known, that of *Bullockornis planei* is the most robust and appears to possess a small distal socket joint, not evident in *Ilbandornis* sp. or *Dromornis stirtoni* (Fig. 27A–C). Both the distal and proximal articular surfaces of the *Ilbandornis* sp. specimen are present, indicating that the bone was short, more or less straight and was not fused to the

palatines as in dromaeognathous birds. Structures and overall proportions are unlike those of any ratite in having mobile joints, the palatine articulation is terminal rather than lateral, and the rostropterygoid facets are situated dorsomedially near the distal end. These features are more similar to galliform and anseriform pterygoids than to those of any other avian order. The quadrate articulation is specifically like those of Anseriformes in its simple ball-and-socket configuration. The palatine articulation of *Bullockornis planei* and perhaps that of *Dromornis stirtoni*, which is damaged in this area, appear to have been differentiated into a dorsomedial process and a small ball-and-socket joint or second process, whereas in *Ilbandornis*, the palatine joint shows no evidence of gomphosis and a separate dorsomedial process is absent.

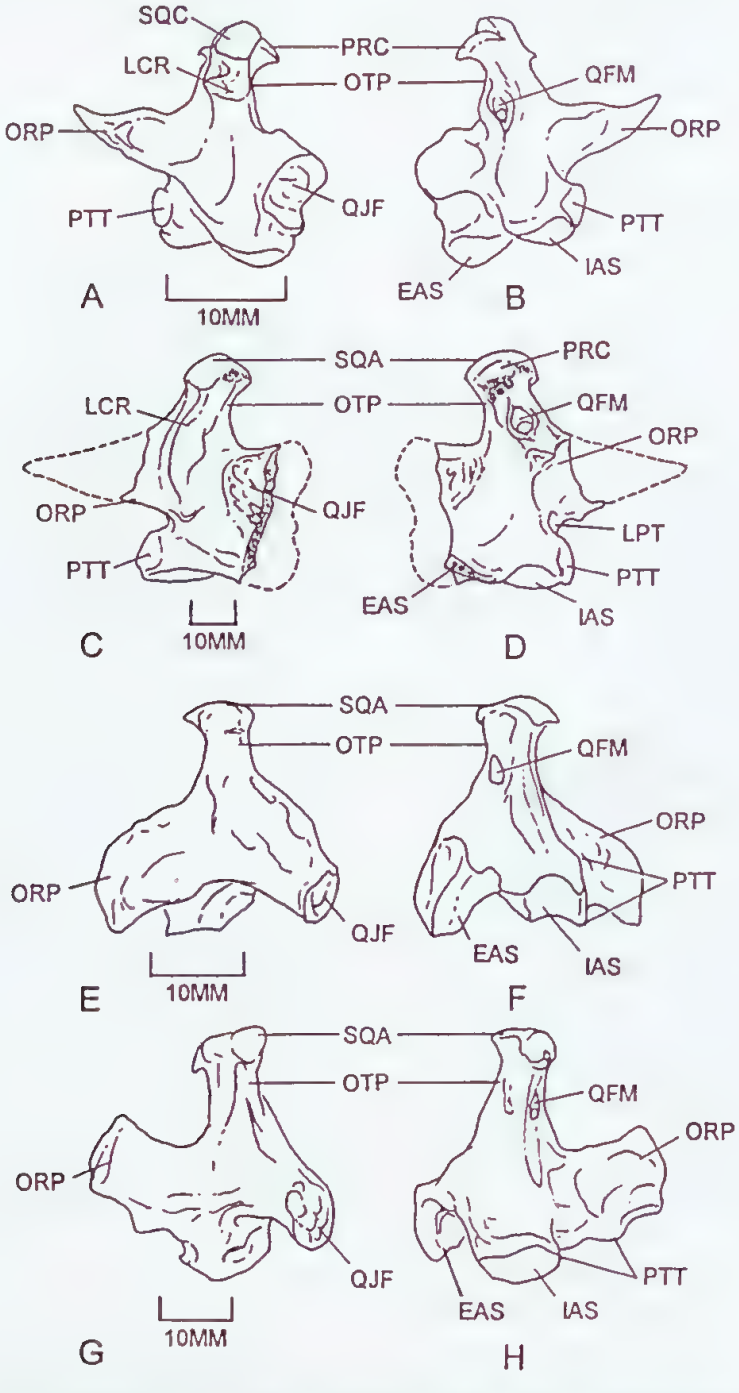


FIGURE 26. Comparison of quadrates in: **A** & **B**, domestic duck, *Anas platyrhynchus*; **C** & **D**, dromornithid, *Bullockornis planei*; **E** & **F**, Emu, *Dromaius novaehollandiae*; **G** & **H**, Ostrich, *Struthio camelus*. Abbreviations: EAS, external articular surface; IAS, internal articular surface; LCR, lateral crest; LPT, scar for pterygoid ligament; ORP, orbital process; OTP, otic process; PRC, pro-otic condyle; PTT, pterygoid tubercle; QJF, quadratojugal facet; SQC/SQA, squamosal articular surface/condyle.

Mandible. The lower jaws of dromornithids are unique among birds in having a pronounced gonial expansion to accommodate its large mandibular adductor muscles. They are also among the deepest avian mandibles relative to their length, surpassing those of *Diatryma*, though less deep in proportion to length than in parrots. Dromornithids have moderately well-developed surangulars, comparable to those of many anseriform birds, but less prominent than in parrots. The coronoids are subdued like those of parrots. The postarticular process is elongated, straight in the sagittal plane, relatively narrow transversely and hooked upwards, a feature to varying degrees of galliform, phoenicopteriform and anseriform birds, but not ratites. Approximately half of the delicate distal point of the postarticular process of *Dromornis stirtoni* is missing (Fig. 17). However, the base of the mediolaterally-compressed process indicates that it curved anterodorsally as in anseriform birds and was not abruptly angled posterodorsally as in galliform birds. The articular fossa is distinctly more galliform or anseriform-like than anything

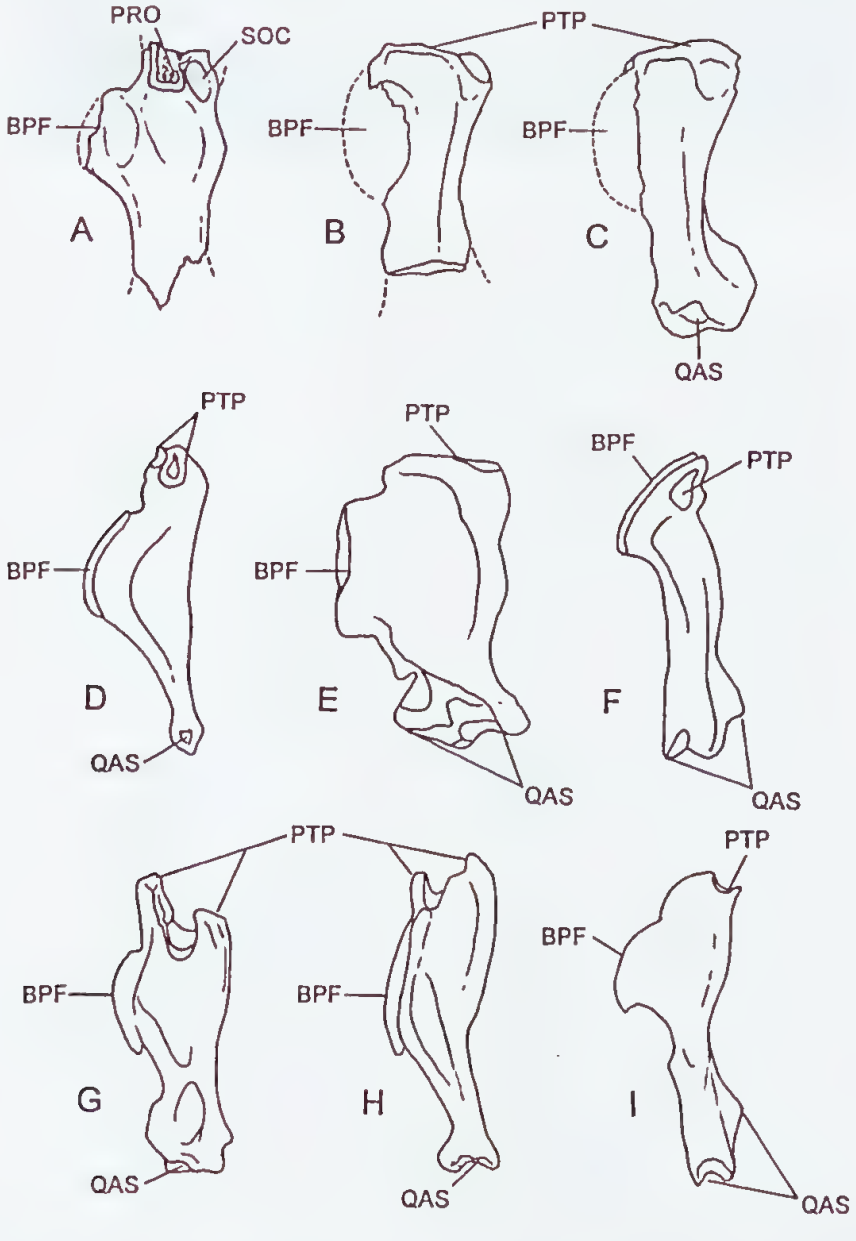


FIGURE 27. Ventral aspects of left pterygoids of: **A**, ?*Bullockornis planei* (Dromornithidae); **B**, *Dromornis stirtoni* (Dromornithidae); **C**, *Ilbandornis* sp. (Dromornithidae); **D**, *Chauna torquata* (Anhimidae); **E**, *Diatryma gigantea* (Diatrymidae); **F**, *Meleagris gallopavo* (Phasianidae); **G**, *Anas* sp. (Anatidae); **H**, *Anseranas semipalmata* (Anseranatidae); **I** , *Megapodius reinwardt*, (Megapodiidae); drawn to the same length for comparison; **D–F** after Andors (1992). Abbreviations: BPF, basipterygoid facet; PRO, base of palatine articular process; PTP, pterygopalatine articular facet; QAS, Quadrate articular surface; SOC, socketed articular surface.

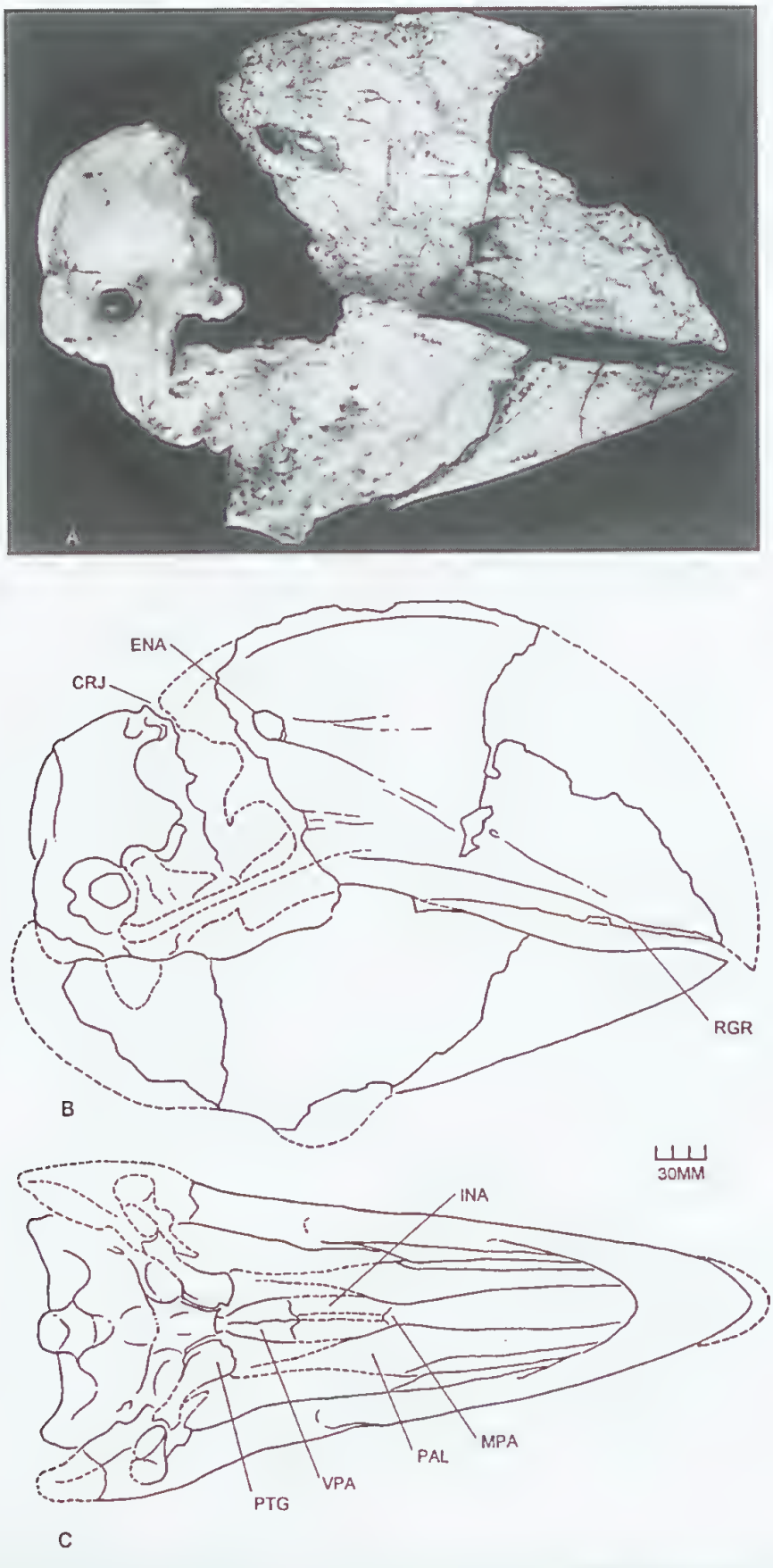


FIGURE 28. Reconstructed elements of the skull of *Bullockornis planei* (P9464–106 cranium; P9464–107 upper beak; P9464–112 mandible); **A**, photograph of reconstructed skull; **B**, line interpretation of lateral aspect, conjectural outlines dashed-in; **C**, line interpretation of ventral aspect. Abbreviations: ENA, external nares; CRJ, cranio-rostral joint; INA, internal nares; MPA, maxillopalatine; PAL, palatine; PTG, pterygoid (based on *Ilbandornis*); VPA, vomeropalatine (fused hemipterygoid-palatine and vomer).

else, and very dissimilar to any ratite. In dromornithids, the posterior mandibular tomia pass outside the uppers as in parrots.

Reconstruction and functional anatomy

Appearance. The skulls of *Dromornis stirtoni* and *Bullockornis planei* are amongst the largest avian crania, rivalling those of *Diatryma* and *Phorusrhacos*. The 460 mm long and 140 mm deep mandible of *Dromornis stirtoni* is about the same size and as robustly constructed as the dentary of a medium-sized horse. The entire skull may have been over 500 mm long. The reconstructed skull of *Bullockornis planei* is slightly smaller. Although the critical area between the frontal and the posterior margin of the upper beak is unknown, the complete mandibles give an accurate indication of their linear proportions and with the quadrate in place, determine the position of the rostral fragments in relation to the cranium (Fig. 28A–C). While large, the skull is by no means disproportional with the postcranial skeleton (Fig. 29), here reconstructed from a combination of *Bullockornis* and *Dromornis* material.

The jaws were long relative to the length of the neurocranium and exceptionally deep, with a slight decurvation of the tip, reminiscent of other large-billed species such as Takahes, puffins, hornbills and cracids but with more specific similarities to the beaks of extinct diatrymatid birds. In dorsal or ventral aspect, the beak is transversely very narrow relative to its height and length and appears to have been much more solidly-constructed than in flying large-beaked birds such as hornbills and toucans.

The main points of conjecture are the anterior orbital region and extent of the rhamphothecae dorsally, and the form of the internal nares and posterior palatines ventrally. Both the upper beak and the mandible of dromornithids have well-developed bony tomial crests indicating deep, thick ramphothecal margins (Fig. 30). In *Bullockornis* the rhinothecal margin appears to have fit inside the gnathothecal crest of the lower jaw. The hollow section of the rhinothecal groove suggests that the tomial surface of the rhinotheca was sulcate, with the lateral margin meeting or slightly overhanging the tomia of the gnathotheca. In species in which the bill sheaths are confined to the tips (nails) and margins, or where the rhamphotheca is thick and actively proliferating, the underlying bone is pitted with numerous foramina. In dromornithids, numerous foramina are concentrated at the tips of the upper and lower beaks and the marginal areas suggesting that much of the upper part of the rostrum and lower part of the mandible was thinly cornified and that well-developed nails were present on the upper and lower bill tips.

The posterior palatine region and form of the internal nares is imperfectly known, but reconstructed on the basis of remnant structures in Figure 28C. It can be discerned that the distal palatines were deep, rather thick vertical crests composed of spongy bone. The posterior element, represented by a fragment of vomeropalatine indicates that the palatines (hemipterygoids) were fused at the mid-line posterodorsally. The width of this fragment suggests that the internal nares were narrow and were probably divided by a short prevomer. The form of the jugal bar is suggested by *Genyornis newtoni*, whereas the shape of the lachrymal is not known.

Functional morphology. Dromornithids have a desmognathous palatal structure very similar to that of ducks, geese and screamers (Fig. 28C). The main difference in the palate relates to the more ventral orientation of the basipterygoid processes relative to the quadratic fossa. This is a proportional adjustment in which the axis of the parasphenoidal rostrum is more inclined in accord with deepening and shortening of the cranium. The deep, short cranium is in turn, a proportional adjustment to the deep rostrum. The quadrates were mobile. Their normal position, with the axis of the body running between the angles of the postorbital process and the base of the opisthotic is indicated by the alignment of the auditory notch between the otic process and the quadratojugal tubercle in relation to the external auditory meatus. With the distal end angled outwards a few degrees and aligned as depicted (Fig. 22C) the articular surface of the quadrates provide sufficient clearance around the neurocranio-mandibular processes and post-tympanic crests for the deeply notched medial surface of the postarticular process.

A rugose crest on the posterodistal margin of the postorbital process indicates the origin of a stout postorbital ligament that inserts on a low tubercle lateral to the external articular process. Depression of the mandible puts tension on the ligament that compels the quadrates to move forward, transmitting the moment through the pterygoids and the quadratojugals to the upper beak, which is elevated accordingly through the dorsal hinge joint. The available leverage for the

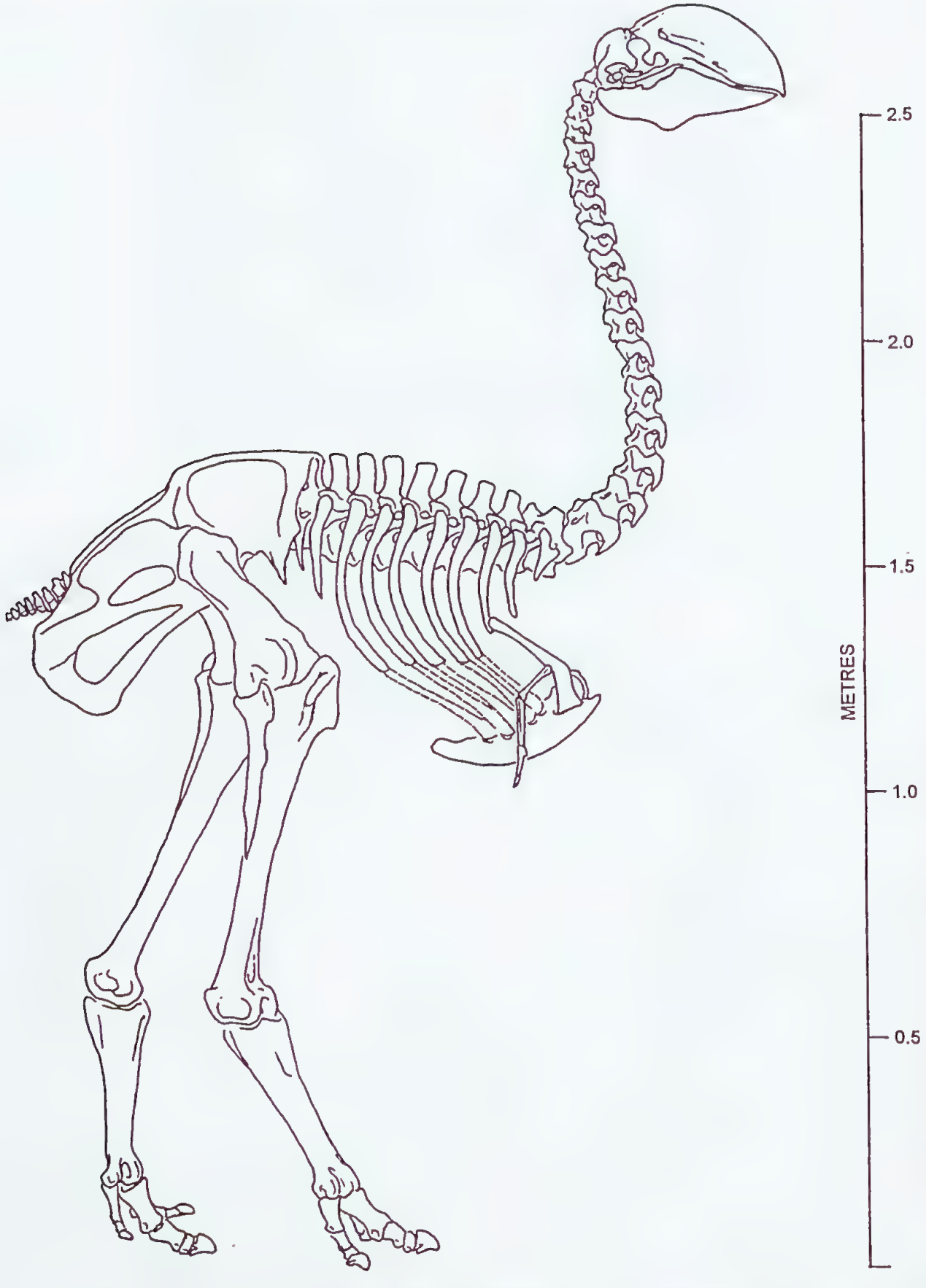


FIGURE 29. Composite reconstruction of dromornithid skeleton, skull and size based on *Bullockornis planei*, postcranial elements based on more complete *Dromornis stirtoni* material. The largest Bullock Creek LF dromornithids were 2.5 to 2.8 metres tall. *Dromornis stirtoni*, the largest Alcoota LF species was 2.7 to 3.0 metres tall. Note massive, short toes, hoof-like unguals and extremely reduced forelimb.

mechanism, as reconstructed (Fig. 28B) would have resulted in a slight elevation of the upper beak as the mandible is depressed.

The median frontal eminence appears to function as a broad fulcrum, probably receiving an overlapping socket joint from the posterior process of the premaxilla. Deep, circular fossae on either side of the eminence may represent reciprocal processes or ligamentous attachments. A distinct cleft may have been present dorsal to the contact over and around which a ligamentous capsule was formed, as indicated by the coronal groove and extensively vascularised dorsolateral surfaces of the frontals (Figs 1A, 2, 3B,C, 28B, 30). The coronal groove, which traverses the dorsal margin of the joint commencing from behind each lateral process of the frontal, is reminiscent of a bursal fossa associated with synovial joints. The lateral process of the frontal seems to anticipate a similar projection of the posterior end of the prefrontal to which it was probably joined by a ligament.

The numerous low crests and foramina indicate the extent and orientation of connective tissue tracts extending in a series of arcs from the frontoparietal toward the sulci and fossae emarginating the rostral contacts with the frontal. A bony hinging mechanism is present below and on either side of the frontal eminence in the form of rectangular flanges extending from the dorsal lamina of the orbits. These flanges are curved dorsally and appear to have smooth ventral contact surfaces. Oval lateral fossae situated above the hinging processes appear to have accommodated reciprocating processes from the rostrum, perhaps from the nasals or lachrymals. The internal surfaces of these fossae are raised into a series of crests that probably represent internal ligaments.

The breadth, depth and apparent complexity of this joint indicates that its purpose transcended a simple transverse hinge arrangement. The compound structure of the joint could accommodate some rotational movement in addition to dorsiflexion of the beak, while also contributing a component of elastic rebound. It is

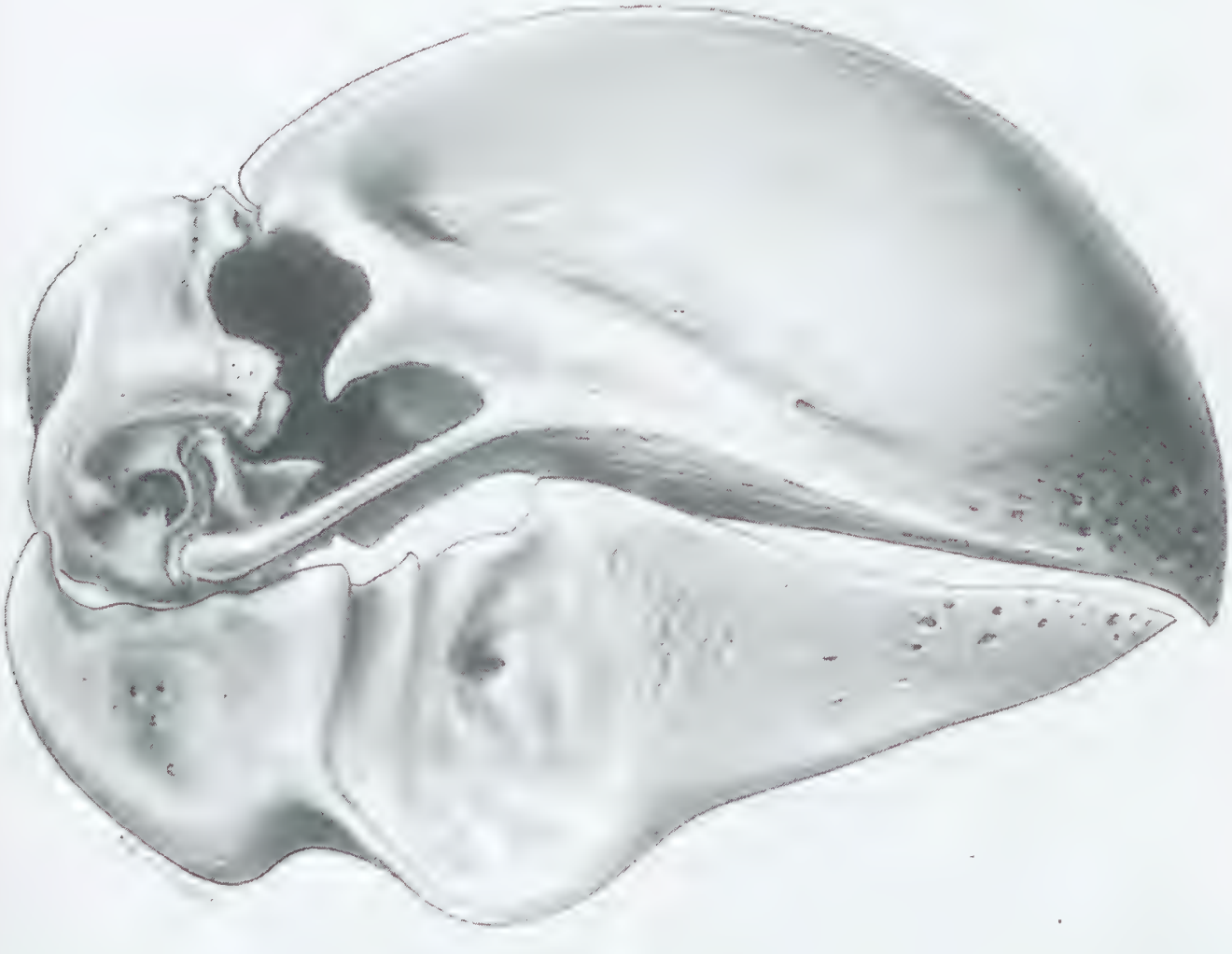


FIGURE 30. Restoration of *Bullockornis planei* skull, anteorbital region and jugal bar are conjectures based on anseriform morphology.

difficult to envision what advantage a small increase in gape resulting from strepsostylic elevation of the beak would offer this large-jawed species. However, passive elevation of the beak during shearing or crushing of hard objects situated closer to the mandibuloquadrate joint would serve to optimise forces by reducing the angle of attack of the tomial margins.

Given the enormous size of the beak and the considerable forces exerted along its length by the powerful adductors, the requirement for such a specialised joint is hardly surprising. The deep fossae for the mandibular adductor muscles laterally and the pronounced internal crest for the posterior pterygoid muscles indicate that enormous shearing forces were exerted at the tomial surfaces. The long muscle bellies and their insertions far anterior to the mandibular fulcrum, in combination with the concave toma of the lower jaw and gently convex toma of the upper, suggest a powerful secateuring action capable of severing tough, firm, fibrous material.

Powerful shearing function in long avian jaws requires that the shearing crests retain their original angle of attack as forces on the material between them are increased during the bite. The deep, slab-sided mandibles and thick, deep, rigid symphysis are essential features of this mechanism, but equally important is the postorbital ligament that resists rotational forces on the ipsilateral mandibulo-quadrate joint. The narrow, parabolic, almost parallel-sided arch of the dromornithid mandible minimises axial distortion or twisting by reducing the amount of leverage between the two rami. In biting through resistant three-dimensional material, such as a sizeable stem or twig, a considerable shock, as the stem suddenly parts, might be expected to travel through the jaws despite proprioceptive reactions of the jaw musculature. We suggest that an important additional function of the cranio-rostral joint specialisation in these genera might be to dampen potentially damaging recoil from biting through resistant plant materials.

The tip of the upper beak is moderately decurved and slightly overhangs the lower. While narrow, the tip is U-shaped rather than pointed. The lower tip is U-shaped and slightly up-turned to form a sharply emarginated scoop. This is clearly a terminal biting mechanism capable of effecting a strong grip at narrow or moderate gape, and biting into or through tough materials at a wider gape. Although the hooked tip appears well-developed in profile, it differs markedly from the slender, sharply pointed hook in raptors and carrion-eating birds, and from the stouter but equally decurved tip of the beaks of parrots, in being transversely broader at the tip, more rounded in external contour and concave on the inner surface along which the margin of the lower beak normally occludes. It is likely that the lower crest could make edge-on-edge contact with the upper with the quadrates drawn forward by action of the protractor quadratus muscles.

The functional attributes of the jaws of the large-beaked dromornithid genera indicate that they were specialised herbivores equipped to shear tough plant materials such as twigs, petioles, fibrous stems, thick, leathery-skinned fruits, leguminous seed pods, large, hard-shelled seeds and fibrous kernel-bearing nuts. The long neck and great stature of the mid to late Miocene species suggest that they were primarily high-level browsers feeding preferentially in the lower branches of trees in a zone between two and three metres above the ground.

Higher avian relationships

Similarities of the dromornithid post-cranial skeleton to those of ratite birds were considered sufficiently compelling to have previously included them in the Palaeognathae (Stirling and Zietz 1913; Cracraft 1973; Rich 1979, 1980). Among the ratite postcranial features shared by dromornithids are absence of a carina on the sternum, unfused furculae, greatly reduced forelimb, and certain functional attributes of the hind limb associated with a cursorial habitus. Detailed character analyses of dromornithids by Rich (1979, 1980) concluded that dromornithids are more closely related to casuariids than any other ratite group.

Consequently we have examined the morphological evidence as closely as our resources allow in an effort to eliminate the possibility of convergence of a basically ratite condition with that of anseriform or other neognathous orders, and to eliminate any possibility that dromornithids represent a novel avian taxon convergent with the Anseriformes. We also compare dromornithid cranial morphology with other extinct large neognathous flightless birds, particularly the diatrymatids.

Dromornithid cranial characters. Primary or diagnostic features of the dromornithid skull include: 1) short, deep cranium with small orbits, lacking occipital fontanelles; 2) narrow anterodorsally-angled parasphenoidal rostrum

terminating behind the base of the maxillary rostrum (upper beak); 3) compressed mesethmoid not continuous or fused with nasal septum; 4) large, flat, basipterygoid (rostropterygoid) facets closely applied to the parasphenoidal rostrum; 5) eustachian canals open confluently on the midline of the basitemporal plate; 6) ventrally excavated postorbital process composed of fused elements, situated anterodorsal to the quadrate fossa, displacing the temporal fossa posteroventrally; 7) mobile quadrates neither bound into, nor abutted against (absent) zygomatic process; 8) broad, rectangular quadrate with strong lateral crest on otic process, presence of faint intercondylar incisure, well-developed quadratojugal buttress and condylar pterygoid articular surface; 9) short pterygoids with distal basipterygoid facets and condylar pterygopalatine joint (possibly with process and socket); 10) proximomedian conjoined palatines not situated lateral to pterygoids; 11) large, wing-like post-tympanic crests in parasagittal plane, opisthotic process traverses base of auditory fenestra; 12) deep fossae in the laterosphenoids for *mm. protractores et levatores quadratus+ pterygoideus*; 13) complex transverse prokinetic cranio-rostral joint situated posteriorly over the orbits with associated ligament tracts and sulci on cranial surface; 14) maxillopalatines fused at midline forming internal nares and median process with articular eminence for the prevomer (desmognathous palatal structure); 15) long, deep laterally compressed beaks; 16) solid lateral wall of upper beak, with deep maxillary process and broad maxillo-nasal contact, maxillopalatines situated ventral to jugal process; 17) small holorhinal external narial aperture; 18) solid, highly-fused mandibular elements, quadratic articular surface divided by distinct *crista intercotyla*, ventral mandibular groove absent and conical recess poorly developed; 19) long, laterally compressed, hooked retroarticular processes oriented in parasagittal plane.

Unique dromornithid characters. The prodigious body size of dromornithids combined with their particularly large skulls introduces conspicuous proportional differences from other bird crania, even in comparison with the largest living and extinct ratite species. Readily identifiable allometric features of the dromornithid cranium are the relatively small size of the orbits, enlarged crests and processes for muscle attachments and differential growth between the inner and outer table of the braincase in which the external surface is considerably expanded by air cells around the endocranial cavity. The posterior position of the basipterygoid facets and apparently very short, upwardly-angled parasphenoidal rostrum appear to be proportional adjustments to the short, deep cranium. Other uniquely dromornithid characters such as the elaboration of the cranio-rostral joint are associated with the large beak and powerful adductors.

Palaeognathae. As the postcranial skeletons of dromornithids were considered to have numerous general and some specific features in common with certain ratite birds, in particular with Casuariidae (Rich 1979), we initially anticipated some ratite similarities in the structure of the cranium and mandibles. The first complete elements recovered were the mandibles, which showed no ratite similarities in structure or form. Previously known quadrate fragments and several pieces of the back of the cranium including the distinctive post-tympanic crests, occipital condyle and orbital margin were also unlike those of any known ratite. Each new fragment rendered the possibility of finding any ratite features increasingly remote, reinforcing Olson's (1985:105) observation that '...if *Genyornis* may be taken as representative of the Dromornithidae as a whole, then this family must have been derived from some group altogether different from the ratites'. Based on some newly prepared Bullock Creek material, Rich (1991) stated that the basicranial structure is not typically ratite or galliform and concluded that the skull is so highly derived that it is difficult to associate them with any known avian group.

We unequivocally confirm Olson's (1985) and Rich's observations (1991) that dromornithids and ratites have no specific cranial attributes in common and that their postcranial similarities, such as can be found, are parallelisms related to flightlessness, cursoriality and large body size. Following Bock's (1963) and Simonetta's (1960) assessments of ratite cranial characters, dromornithids differ from ratites in: 1) possessing a short vomer not anteriorly fused to the palate; 2) the palatines are not laterally deflected; 3) the longer span of the pterygoid is between the quadrate and the basipterygoid facet, and the pterygopalatine joint is a mobile synovial joint; 4) the basipterygoid facets are situated more anteriorly on the parasphenoidal rostrum and lack stalk-like processes; 5) the orbital and nasal septae are not continous and a transverse nasofrontal hinge is present; 7) the maxillary processes of the upper beak appear to have been

fused to the descending process of the nasals and 8) the quadrate is independent of the zygomatic process, neither abutted to it, nor rendered sessile in its proximity by ligaments. Some additional, utterly non-ratite attributes include: 9) absence of zygomatic process or fusion of its homologue to the postorbital process, displacing the temporal fossa to behind and below the squamosal component rather than between the postorbital process (frontal) and zygomatic process (squamosal); 10) anteroposteriorly oriented, wing-like form of the opisthotics; 11) topology of the basicranial foramina and narrowness of the basitemporal plate; 12) confluent median emergence of the eustachian canals; 13) form and relations of the quadrate fossa; 14) morphology of the quadrates; 15) relations and form of the auditory meatus; 16) fusion of mesethmofrontal and form of interorbital septum and 17) median fusion of the maxillopalatines excluding the vomer (desmognathous palatal structure).

Psittaciformes. Rich (1991) noted several parrot-like similarities to dromornithids which are considered to be convergences related to herbivorous diet. These include large, powerful rostrum; small, holorhinal external nares; mobile, wide cranio-rostral joint and simple-headed quadrate.

Ciconiiformes. Similarities between dromornithids and ciconiiform birds include desmognathous palate, holorhinal nostrils and prenarial furrows or grooves. The maxillopalatines of threskiornithids, (*Threskiornis, Platalea*) are hypertrophied and spongy, filling the base of the beak much as in *Bullockornis*. However the complex condylar morphology of the quadrate, absence of parasphenoidal and pterygoid basipterygoid facets, transversely expanded and inferiorly directed postarticular processes of the mandibles in this order differ substantially from the equivalent structures in dromornithids. Ericson (1997) considers Ciconiiformes to represent the sister-group of Phoenicopterids.

Phoenicopteriformes. Flamingos, like threskiornithids, have hypertrophied, spongy maxillopalatines in common with dromornithids. They also resemble anseriform birds in possessing prolonged, recurved postarticular processes. However the basipterygoid processes are rudimentary and the cranium is otherwise similar to the Ciconiiformes with which they are sometimes included as a family. Ericson (1997) places phoenicopterids as the sister-group to Anseriformes. The long neck and large, down-curved beak of the flamingo imparts a superficial resemblance to our reconstruction of *Bullockornis* (Fig. 28).

Gruiformes. With the exception of desmognathous cariamids, all other gruiform birds are schizognathous and all lack basipterygoid processes. The postarticular processes are truncated and transverse. Diatrymatids were considered to have been related to Gruiformes during the late nineteenth century (Andors 1992). Gruiform birds have no particular similarities with dromornithids.

Charadriiformes. Olson and Fedducia (1980) conclude that Anseres were derived from Charadriiformes based on a mosaic of characters in *Presbyornis*. Charadriiform ancestry of Anseriformes is rejected by both Livezey (1997) and Ericson (1997).

Galliformes. Livezey (1997) and Andors (1992) recognise Galliformes as the sister-group of the Anseriformes. Galliform birds, in common with Anseriformes and Dromornithidae have well-developed rostropterygoid facets and elongated, reflected postarticular processes. They also share similarities in the mandibular articulation and suspensorium (Andors 1992). The curassow-like beak, holorhinal nostril and imperforate occiput of dromornithids are also reminiscent of galliforms. However, Galliformes are schizognathous and show a number of differences in the cranium, in which a secondary temporal arcade is usually present (Fig. 23C) and in specific features of the quadrate (wide incisure of otic process, weak adductor crest, truncated medial mandibular condyle) and postarticular process (shallower, less compressed, shorter).

Anseriformes. Dromornithids and anseriform birds, exemplified by screamers, ducks and geese, exhibit a considerable number of close morphological similarities that are not found *en suite* in other avian species. Among these are: the possession of rostropterygoid facets closely applied to the parasphenoidal rostrum; excavated postorbital process and absence of zygomatic process; topology of the cranial base and its foramina; form and anteroposterior orientation of the post-tympanic crests of the opisthotics; overall similarity of the quadrates (intercondylar incisure shallow, large adductor crest, elongated obliquely

oriented medial mandibular condyle); short distal process of the pterygoid with socket and process (in part) and distomedial position of basipterygoid facets; hemipterygoids fused to prevomer; maxillopalatines fused in mid-line forming anterior margin of internal nares (desmognathous palate); deep fossae in the laterosphenoids for the *mm. protractores et levatores quadrati+ pterygoidei*; morphology of the endocranial cavity, and long, compressed, upturned postarticular processes. While some features (e.g. form of basipterygoid [rostropterygoid] processes and distal basipterygoid facets of the pterygoids) are shared with galliform birds, the form of the quadrates, possession of desmognathous palate and form of the postorbital process and temporal fossa are sufficient grounds for rejecting a galliform relationship.

In terms of character states with widely agreed upon polarity determinations (Andors 1992, Livezey 1997, Ericson 1997), the Dromornithidae are synapomorphous with Anseriformes in possessing: 1) rostropterygoid facets as opposed to true basipterygoid processes; 2) postorbital process concave posteriorly, zygomatic process absent; 3) hooked, compressed retromandibular process in sagittal plane; 4) prominent medial mandibular process; 5) articular fossa of mandible divided by prominent intercondylar crest; 6) craniofacial flexion zone transverse, buttressed by eminences of the frontal; 7) absence of rhynchokinesis; 8) maxillopalatine forming continuous osseous palate; 9) (possible) rudimentary gomphosis (in part) of pterygopalatine articulation; 10) presence of tubercle for adductor mandibularis muscle on lateral surface of the quadrate.

Relationship to diatrymatids and anhimids. Andors (1992) considers the large flightless Euramerican Palaeogene birds of the genus *Diatryma* to represent the sister group of the Anhimidae (Screamers) which are in turn placed within the Anseriformes as the sister group to the Anseranatidae (Magpie geese) and the Anatidae (typical ducks and geese). This hypothesis has much in common with the present observations on dromornithid relationships. While the diatrymatid characters employed in Andors' (1992) cladistic analysis pertain as much to the postcranial skeleton as to the skull, several important features can be compared. The palatal and cranial base elements of all *Diatryma* species are poorly preserved, but such as exist indicate a desmognathous palate.

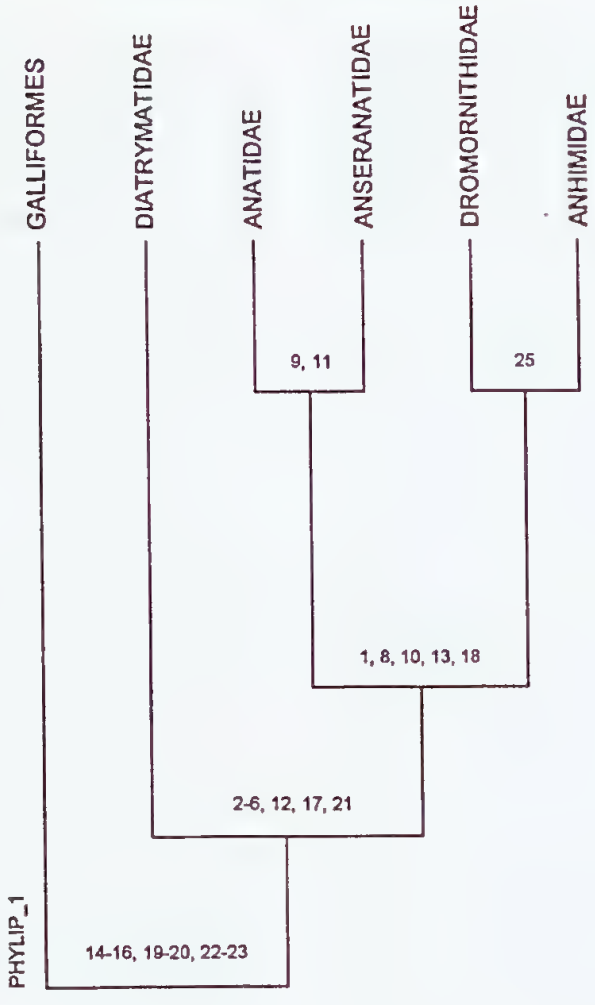
More detailed similarities include a greatly shortened neurocranium, large compressed, moderately hooked (non-raptorial) beak, solidly fused mandibular elements with elongated hooked, retroarticuar processes, prominent and massive post-tympanic crest, basic form of the pterygoids, broad quadrate with well-developed anterolateral crest or process for the *m. adductor mandibulae externus*, and condylar articular tubercle for the pterygoid, while however, retaining a distinctly separated pro-otic condyle, reduced and/or poorly differentiated in dromornithids.

A conspicuous similarity is the small, posteriorly situated holorhinal external narial aperture. The postcranial skeleton of *Diatryma* is clearly less specialised than in dromornithids in the retention of digit I, a pygostyle, and less reduction of the forelimb. As in anhimids and dromornithids, the diatrymatids lack uncinate processes (Matthew and Granger 1917, Andors 1992). As Andors (1992) points out, *Diatryma* retains many galliform symplesiomorphies, among which he includes the holorhinal impervious nares, upper temporal fenestra, and simple abutting pterygo-palatine articulation.

With the exception of the (possibly homoplasious) absence of uncinate processes, dromornithid-anhimid similarities are largely symplesiomorphic within Anseriformes, based on character polarities determined by Andors (1992) and Ericson (1979), e.g.: 1) absence of occipital fontanelles; 2) angled parasphenoidal rostrum; 3) absence (in part) of pterygopalatine ball and socket joint; 4) narrow beak; 5) shallow conical recess of mandible; 6) presence of pneumatic foramen of medial mandibular process; 7) absence of ventral groove in anterior portion of mandible.

Possibly of phylogenetic significance is the difference between the basipterygoid processes of anhimids and dromornithids (and all other Anseriformes). Anhimids appear to have a true (reptilian-type) basipterygoid articulation (Ericson 1997) whereas dromornithids clearly possess rostropterygoid articulations with marked similarities to those of *Anseranas* (Fig. 25A,B). The basipterygoid articular surface of the pterygoid is also closer to mid-shaft position in anhimids (Fig. 27D), whereas in dromornithids and all other Anseriformes, the facet is situated at its distal extremity. Given the wide range of expression of basipterygoid articulation within other non-passerine orders, the anomalous condition in the Anhimidae might be interpreted as a reversal.

The inclusion of the characters of *Bullockornis*,



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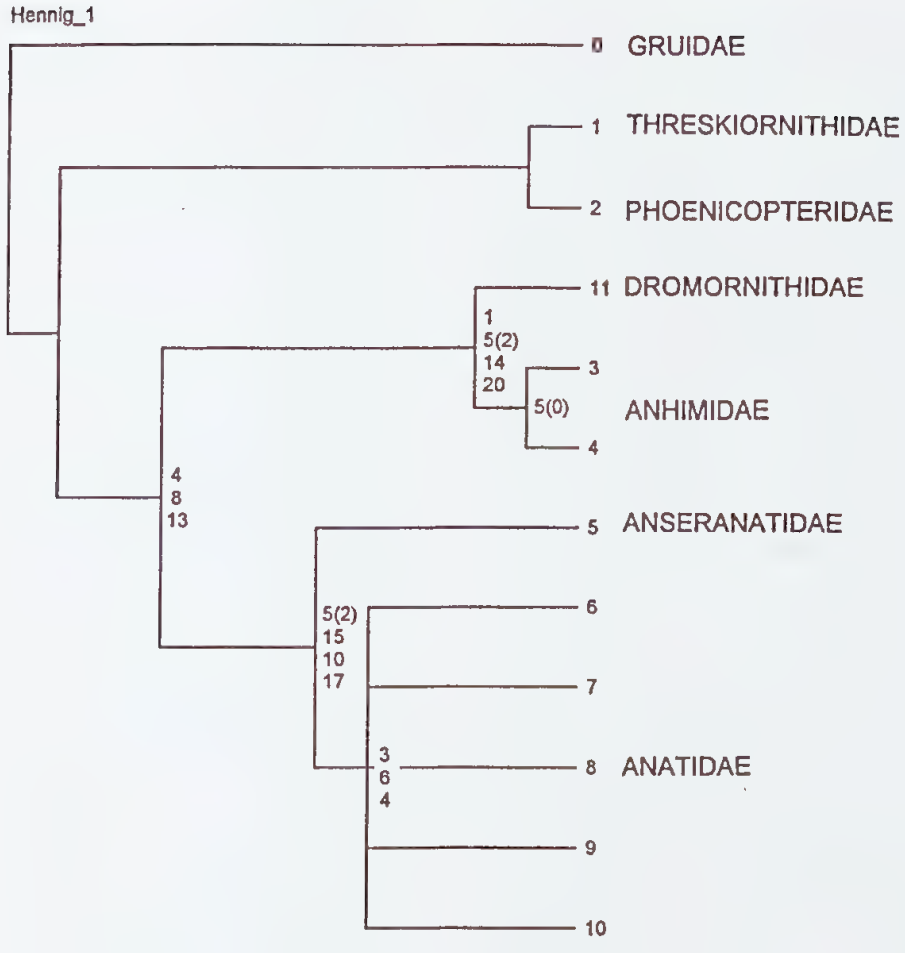
GALLIFORMES	0	0	0	0	0	0	0	0	0	0	0	0	0	P	1	1	0	0	1	1	0	1	P	1	0
DIATRYMATIDAE	0	1	1	1	1	1	1	0	0	?	0	1	0	1	1	1	1	0	1	1	1	1	1	0	?
ANHIMIDAE	1	0	0	1	1	1	1	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1
ANSERANATIDAE	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
ANATIDAE	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
DROMORNITHIDAE	?	1	1	1	?	?	0	1	0	1	0	1	1	?	1	1	1	1	1	1	1	1	1	0	1

FIGURE 31. Dendrogram of dromornithid relationship within Anseriformes based on character states **1–25** (skull+two postcranial characters) abridged from Andors (1992), *Megapodius* (Galliformes)=outgroup species; polarity code (see Andors 1988, 1992 for full descriptions): 0=primitive, 1=derived; defined as follows: **1,** nasal septum: imperforate 0; perforate 1; **2,** external nares: elongate 0; restricted to posterior position 1; **3,** premaxilla labial process: slender 0; deep 1; **4,** nasal-frontal hinge: flexion zone indistinct 0; distinct crease 1; **5,** lacrimal head: joined to nasal bar 0; moderately developed or large, situated beneath nasofrontal hinge 1; **6,** lacrimal descending process: poorly developed and pointed 0; short, broad 1; **7,** orbital rims: thin 0; thick 1; **8,** zygomatic process: forms a temporal fenestra 0; temporal fossa reduced, displaced posteroventrally 1; **9,** occipital fontanelles: absent 0; present 1; **10,** bony palate: schizognathous 0; desmognathous 1; **11,** pterygoid: pterygo-palatine articulation: simple abutment or peg and socket 0; ball and socket involving two extensions of pterygoid 1; **12,** pterygoid: position of basipterygoid facets, anterior 0; medial, forming an extensive flange; **13,** basipterygoid processes: sessile 0; almost pedicellate 1; **14,** quadrate: otic process, wide incisure 0; narrow or obsolete incisure 1; **15,** quadrate: anterolateral crest or process, absent 0; present 1; **16,** quadrate: mandibular condyles, three in number, v-shaped configuration 0; two in number, bilobate lateral condyle larger more bulbous than medial 1; **17,** quadrate: medial condyle, rounded, truncated medially 0; compressed, elongated anteromedially 1; **18,** quadrate: posterior buttress of jugal, small 0; large 1; **19,** mandible: articular fossa, v-shaped 0; bipartite, cotyla and intercotylar crest directed anteromedially 1; **20,** mandible: lateral mandibular process, unknown state 0; rounded and prominent 1; **21,** mandible: medial mandibular process, spike-like, without anterior facet 0; expanded distally and facetted; **22,** mandible: retroarticular process, absent or poorly developed 0; long, upwardly curved 1; **23,** mandible: retroarticular process, slender and rounded 0; laterally compressed and blade-like 1; **24,** caudal vertebrae: hypocentra, well developed 0; poorly developed 1; **25,** ribs: uncinate processes, present 0; absent 1. PHYLIP (Felsenstein 1995), Wagner parsimony, 1 tree; 23 steps.



		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	*Grus*	1	0	0	1	0	0	0	0	0	1	0	0	0	?	0	0	0	1	0	0
1	*Threskiornis*	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
2	*Phoenicopterus*	1	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
3	*Anhima*	0	0	0	1	0	0	0	1	0	0	1	1	1	0	0	0	0	1	1	1
4	*Chauna*	0	0	0	1	0	0	0	1	0	0	1	1	1	0	0	0	0	1	1	1
5	*Anseranas*	1	0	0	1	2	0	1	1	1	1	1	1	1	1	0	1	1	1	0	0
6	*Dendrocygna*	1	0	1	1	2	1	1	1	1	1	1	1	1	2	1	1	1	0	0	0
7	*Thalassornis*	1	0	1	1	2	1	1	1	1	1	1	1	1	2	1	1	1	0	0	0
8	*Stictonetta*	1	0	1	1	2	1	1	1	1	1	1	1	1	2	1	1	1	0	0	0
9	*Anser*	1	0	1	1	2	1	1	1	1	1	0	1	1	2	1	1	1	0	0	0
10	*Tadorna*	1	1	1	1	2	1	1	1	1	1	0	1	1	2	1	1	1	1	0	0
11	*Bullockornis*	0	0	0	1	2	?	0	?	0	0	1	1	1	0	0	1	0	0	0	1

FIGURE 32. Dendrogram depicting dromornithid relationships within Anseriformes based 17 cranial and three postcranial characters abridged from Ericson's (1997) matrix; Gruidae (*Grus*) outgroup; characters and polarity code (see Ericson [1997] for full descriptions): **1**, occipital fontanelles: present 0; absent 1; **2**, frontal narrow and laterally rounded, yes 0; no 1; **3**, cranium and lacrimals co-ossified: unfused 0; fused 1; **4**, ventral surface of postorbital process distinctly excavated: no 0; yes 1; **5**, basipterygoid processes: true (reptilian) 0; absent 1; rostropterygoid 2; **6**, ventral margin paraspenoidal rostrum: clearly angled 0; gradually sloping 1; **7**, pterygopalatine articulation ball and socket with 2 processes: no 0; yes 1; **8**, internal lamina of pterygoids obsolete: no 0; yes 1; **9**, position of jugal process of maxilla relative to maxillopalatine: dorsal 0; ventral 1; **10**, bill broad, spatulate: no 0; yes 1; **11**, quadrate, lateral view: not squarish, deeply curved dorsal margin 0; squarish, dorsal margin straight 1; **12**, quadrate, mandibular process inflated behind quadratojugal articulation; no 0; yes 1; **13**, mandible, quadrate articulation: three-condyle articulation with medial and lateral cotyla separted by a shallow groove 0; two-condyle articulation with medial and lateral cotyla separated by an anteroposteriorly oriented intercotylar crest 1; **14**, mandible, conical recess: absent 0; shallow 1; deep 2; **15**, mandible, pneumatic foramen in medial mandibular process: present 0; absent 1; **16**, mandible, lateral mandibular process: absent 0; present 1; **17**, mandible, groove in ventral surface of anterior portion of mandibular rami: absent 0; present 1; **18**, thoracic vertebrae, notarium present: yes 0; no 1; **19**, caudal-most thoracic vertebrae are pleurocoelous: no 0; yes 1; **20**, uncinate processes on ribs: present 0; absent 1. HENNIG 86 version 1.5 (Farris 1988); consistency index= 0.78, retention index= 0.91, Nelson consensus based on 4 trees.

Dromornis and *Ilbandornis* in Andors' (1992) matrix of character states for the skull and two postcranial states (Andors' characters 1-25) with Galliformes outgroup results in a phylogenetic hypothesis that recognises dromornithids as the sister group of anhimids and diatrymatids as the sister group of Anseriformes (Fig. 31). As Andors (1992) found with *Diatryma*, dromornithids express a mosaic of character states. In the case of dromornithids, some characters are highly derived in the direction of anseranatids and anatids (rostropterygoids, temporal fossa-auditory region and quadrate morphology) and others that are plesiomorphic anhimid and galliform-like states (non-spatulate bill, absence of ventral groove, composite structure of postorbital process, simple (in part) pterygopalatine articulation).

It is possible that some derived characters are parallel developments while others, such as the simple, galliform-like abutting pterygopalatine joint in *Ilbandornis*, might represent a secondary (reversed) state. In general, the dromornithids appear to be far more derived in the direction of anhimids, anseranatids and anatids than are the diatrymatids. This phylogenetic hypothesis seems compatible with the phenetic or synmorphological appraisal of the descriptions and comparisons above, and implies that the loss of flight and certain similarities in cranial structure between dromornithids and diatrymatids are parallelisms.

Using Ericson's (1997) rather different matrix of cranial characters and two postcranial states (characters 1–20), with *Grus* as outgroup, the position of the Dromornithidae as the sister group of the Anhimidae remains the same, regardless of the recognition of different types of basipterygoid articulations and change of outgroup (Fig. 32). While the position of dromornithids among Anseriformes is unaffected by the two different outgroup selections, the position of diatrymatids, in having possible closer affinity with Galliformes (Andors 1992) might change in the context of Ericson's (1979) more inclusive matrix.

Biogeography

The ratite-dromornithid hypothesis is elaborated by Cracraft (1973) who stresses cladistic patterns as the keystone to understanding biogeographic distributions. Rich's (1979, 1980) cladogram depicting dromornithids as ratites based on postcranial characters provides a neat correspondence to the pattern of southern continents in the late Jurassic-early Cretaceous. However, the anseriform hypothesis of dromornithid relationships provides an equally plausible palaeobiogeographic scenerio.

Anhimids probably represent the most primitive anseriform states and although their earliest records are from the Palaeogene of North America (Andors 1992), it is possible that they originated in the Southern hemisphere during the Cretaceous Period. Anhimids are presently endemic to South America and may, despite their excellent flying capabilities, represent a relict Gondwanan radiation (Livezey 1997). It is possible that dromornithids may have predated the arrival of casuariids which entered Australia via land connection with Antarctica at some time before about 45 million years ago.

As with many rallid species, which arrived on various continents and islands by flying there, later to become partially or wholly ground dwelling, it is possible that an anhimid-like ancestor of dromornithids adapted to a cursorial habitus in the initially ratite-free Australian land mass. Andors' (1992) observations on the herbivorous bulk-feeding diet being disadvantageous to a flying animal are appropriate here. The high diversity of mid to late Tertiary dromornithids suggests that they had commenced radiation before the arrival of casuariids, which have maintained a comparatively low diversity at least since the mid-Tertiary.

The phylogenetic implications of dromornithid biogeography are that primitive Laurasian Anseromorphae gave rise to gastornithiforms (diatrymatids+gastornithids) (Andors 1992) and ancestral anhimids, the latter having either originated in, or migrated to South America where they radiated and dispersed to Australia and perhaps Antarctica. Dromornithids arose from a terrestrially adapted anhimid-like bird that paralleled the diatrymatids in skull morphology and converged with ratites in postcranial morphology.

Conclusions

In proposing anseriform affinity of dromornithids on cranial evidence alone, it is important to recollect that the postcranial skeletons of Dromornithidae have long been considered to be very similar to those of ratites, particularly the casuariids. In addition to the long neck, extreme reduction of the wing and loss of carina and apparent similarities of the hind limb segments, down to the detail of loss of the hallux have been recognised. Rich (1981) identified 19

shared derived states between dromornithids and casuariids. Differentiation within the Dromornithidae resulted in a range of postcranial adaptations from Ostrich-like (*Ilbandornis*) to gigantic cursorial forms with somewhat Cassowary-like ratios of the limb segments (*Dromornis*), (Stirling and Zietz 1913; Rich 1979, 1981).

Our nearly completed re-evaluation of the dromornithid postcranial skeleton fully supports the cranial evidence for anseriform affinity, but also does not find as a high degree of convergence as might be anticipated, in the synsacrum and hind limb with struthioniformes (Casuariidae and Struthionidae) or any other palaeognathous ratite. Relative hind limb segment lengths of at least two genera of dromornithids are more similar (*Genyornis newtoni* is identical) to that of *Anseranas semipalmata* (Magpie goose) than to those of any ratite. Structural convergences with Struthioniformes are confined to hypertrophy of a single hypotarsal ridge (non-homologous, as different calcaneal ridges are involved) and homoplasious loss of hallux. Conversely, numerous symplesiomorhic states with galliform and anseriform birds are evident, and several clearly defined anseriform synapomorphies are present in states of sacrum, distal femur, proximal tibiotarsus, and proximal tarsometatarsus.

The possibility of convergence in some morphological complexes emphasises the necessity to examine and compare all anatomical components as widely and in as much detail as the specimens permit. Our observations suggest that many, if not all of the character similarities that have been proposed between dromornithids and ratites are isolated expressions within very different morphological complexes that are disjunct in relation to well-defined morphoclines among purportedly related taxa. Though previous understanding of the ordinal affinity of dromornithids was impeded by the poor preservation of the skull of *Genyornis newtoni*, in the clarity of hindsight, it is also evident that the specimen exhibits sufficient morphological information to have distinguished the dromornithids from the palaeognathous ratites and to have at least recognised their affinity with neognathous birds nearly a century ago.

Palaeontologists who have examined dromornithid material, from Stirling and Zietz (1913), Olson (1985), to Rich (1979, 1980, 1991) have expressed varying degrees of ambivalence about the ratite affinity of dromornithids; in the first place, due to the distinctive morphology of the quadrates and secondarily, due to the absence of any specific character state in the postcranial skeleton that would link them unequivocally to a particular group of ratites. In spite of much conflicting evidence from other parts of the skeleton, the reduced forelimb, acarinate sternum and large size of dromornithids seems to have overwhelmed consideration of any other avian orders. Consequently, with comparisons confined solely to ratites, irrespective of the method of analysis, the only conclusion that could be drawn was that dromornithids were aberrant ratites. This ambiguity of dromornithid relationships has had an effect on their visibility in the literature. Despite the fact that more is known about them than many other gigantic fossil birds, they are only rarely mentioned in general accounts of fossil vertebrates and often ignored in systematic and biogeographic works.

We hope, therefore, that our conclusions, briefly summarised below, will assist in dispelling the perception of the Dromornithidae as the poor relatives of Emus and Cassowaries or as an obscure group of Australian ratites of unknown affinity. Dromornithids actually comprise a large and venerable radiation of uniquely Australian gigantic birds, closely related to screamers, ducks and geese. Unlike casuariids, which are rare as fossils in the Tertiary, dromornithids are abundant and diverse components of Australian Miocene-Pliocene vertebrate palaeocommunities, representing around 25% of the material in Northern Territory Miocene local faunas at Camfield and Alcoota (Murray and Megirian 1992). Elsewhere, dromornithids persisted locally in large numbers as *Genyornis newtoni* until their extinction in the late Pleistocene (Field and Boles 1998).

1) Four genera of Dromornithidae, *Bullockornis, Dromornis, Ilbandornis* and *Genyornis,* are represented by cranial material, *Bullockornis planei* being the most complete. While considerable morphological diversity is shown among these genera, they comprise a well-defined natural group appropriately included in a single family.

2) Two basic trophic adaptations in dromornithids are indicated by the available material. *Bullockornis* and *Dromornis* are characterised by deep, powerful beaks in contrast to *Ilbandornis* and *Genyornis* which have more slender, relatively more elongated beaks. Dromornithids were bulk-feeding vegetarians capable of cropping and breaking into extremely tough plant materials. The tomia of the beaks are differentiated into anterior cropping and posterior shearing functions.

3) Dromornithids had prokinetic crania characterised by a complex cranio-rostral joint composed of a median frontoethmoidal tuberosity, lateral fossae and an extensive ligamentous joint capsule. This mobile joint surface facilitated elevation of the beak during depression of the mandible, and also may have functioned as a dampening mechanism for the absorption of twisting and recoil resulting from sudden failure of resistant plant material.

4) Because of their enormous size, dromornithid skulls have many unusual features attributable to allometry. The orbits are small, the neurocranium is short, crests for muscular attachments are exceptionally large. It is likely that a combination of allometric features and trophic specialisations account for some of the similarities of *Bullockornis* to *Diatryma* that, though they are remotely related within the Anseramorphae, might be mistaken for shared derived characters. These allometric features of giant anseramorphs are in stark contrast to the ratites in which the heads appear disproportionately small relative to their bodies and in which allometrically-controlled proportional sliding is not as pronounced.

5) Dromornithids are placed within the Anseriformes on the basis of shared similarities in the structure of the palate (desmognathous), detailed similarities of the quadrate, structure of the postorbital process and the temporal fossa, distinctive pit-like fossa for the protractor and levator quadratus and pterygoideus muscles in the pterosphenoid, and distinctive form of the basipterygoid (rostropterygoid) processes. The rostropterygoid processes of anseriform and galliform birds appear to arise from a different region of the parasphenoid and develop later than the typical basipterygoid processes of palaeognathous and several neognathous orders (Weber 1993, Livezey 1997). Specific morphological details of these and other structures analysed by Andors (1992) with regard to diatrymatids, indicate that dromornithids represent the sister-group of screamers (Anhimidae). Consequently, supposed ratite-like postcranial features of dromornithids are convergences stemming primarily from the assumption of large body mass and secondarily from terrestrial locomotor specialisation.

6) The postulated close relationship of dromornithids to anhimids has implications for the interpretation of anseriform palaeobiogeography. Because dromornithids may represent an early Gondwanan radiation, it seems more parsimonious to postulate that the anhimids were in the Southern hemisphere, presumably South America, during the Cretaceous and may have originated there. Consequently, while primitive Anseramorphae may have originated in Laurasia, the Anseriformes may have Gondwanan origins.

7) The high diversity and extreme specialisation of dromornithids suggests that their radiation in Australia antedates that of the casuariids. Casuariids show two basic adaptive extremes with minor speciation in each, indicative of a broad spectrum of niche occupation previous to their arrival and establishment on the continent.

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References

ANDORS, A.V. 1992. Reappraisal of the Eocene groundbird *Diatryma* (Aves: Anserimorphae). Pp. 109–125 *In*: 'Papers in avian paleontology honoring Pierce Brodkorb'. Ed. K. E. Campbell. Science series No. **36**: 109–125. Natural History Museum of Los Angeles County.

BOCK, W. J. 1963. The cranial evidence for ratite affinities. *Proceedings of the XIII International Ornithological Congress* Vol **1**: 39–54.

CHRISTIDIS, L. & BOLES, W. 1995. The taxonomy and species of birds of Australia and its Territories. *Royal Australian Ornithologists Union Monograph* **2**.

CRACRAFT, J. 1973. Continental drift, palaeoclimatology, and the evolution and

biogeography of birds. *Journal of Zoology, London* **169**: 455–545.

DE BEER, G. 1957. The evolution of ratites. *Bulletin of the British Museum (Natural History), Zoology* **4**: 59–70.

ERICSON, G. P. 1997. Systematic relationships of the Palaeogene family Presbyornithidae (Aves: Anseriformes). *Zoological Journal of the Linnean Society* **121**: 429–483.

FIELD, J. H. & BOLES, W. E. 1998. *Genyornis newtoni* and *Dromaius novaehollandiae* at 30,000 b.p. in central northern New South Wales. *Alcheringa* **22**, 177–188.

FÜRBINGER, M. 1888. *Untersuchungen zur Morphologie und Systematik der Vögel.* Amsterdam.

GOODRICH, E. S. 1958. *Studies on the structure and development of vertebrates Vol. 1.* Dover Publications, New York.

HEILMANN, G. 1926. *The origin of birds.* London.

HUXLEY, T. H. 1867. On the classification of birds; and on the taxonomic value of the modifications of certain of the cranial bones observable in that class. *Proceedings of the Zoological Society of London* **1867**: 415–472.

LIVEZEY, B. C. 1997. A phylogenetic analysis of basal Anseriformes, the fossil *Presbyornis*, and the interordinal relationships of waterfowl. *Zoological Journal of the Linnean Society* **121**: 361–428.

MATTHEW, W. D. & GRANGER, W. 1917. The skeleton of *Diatryma*, a gigantic bird from the Lower Eocene of Wyoming. *Bulletin of the American Museum of Natural History* **37**(11): 307–326.

MCDOWELL, S. 1948. The bony palate of birds. Part I, the Palaeognathae. *Auk* **65**: 521–549.

MURRAY, P. F. & MEGIRIAN, D. 1992. Continuity and contrast in middle and late Miocene vertebrate communities from the Northern Territory. *The Beagle, Records of the Northern Territory Museum of Arts and Sciences* **9**(1): 195–218.

OLSON, S. L. & FEDUCCIA, A. 1980. *Presbyornis* and the origin of the Anseriformes (Aves: Charadriomorphae). *Smithsonian Contributions to Zoology* **323**: 1–24.

OLSON, S. L. 1985. The fossil record of birds. Pp. 79–283 *In* 'Avian Biology', **VII**, Ed. D. S. Farner, J. R. King & K. C. Parkes. Academic Press, New York.

OWEN, R. 1872. Untitled. *Proceedings of the Royal Zoological Society of London* **1872**: 682–683.

PYCRAFT, W. P. 1901. On the morphology and phylogeny of the Palaeognathae (Ratitae and Crypturi) and Neognathae (Carinatae). *Transactions of the Zoological Society of London* **15**: 149–290.

RICH, P. V. 1979. The Dromornithidae. *Bureau of Mineral Resources, Geology and Geophysics, Australia, Bulletin* **184**.

RICH, P. V. 1980. The Australian Dromornithidae: a group of extinct large ratites. *Contributions in Science. Natural History Museum of Los Angeles County* **330**: 93–104.

RICH, P. V. 1991. The Mesozoic and Tertiary history of birds on the Australian Plate. Pp. 721–808 *In* 'Vertebrate palaeontology of Australasia'. Ed. P. Vickers-Rich, J. M. Monaghan, R. F. Baird, & T. H. Rich. Pioneer Design Studio and Monash University Publications Committee: Melbourne.

SIMONETTA, A.M. 1960. On the mechanical implications of the avian skull and their bearing on the evolution and classification of birds. *Quarterly Review of Biology* **35**: 206–220.

STIRLING, E. C. & ZIETZ, A. H. C. 1913. Fossil remains of Lake Callabonna, Part IV. Description of some further remains of *Genyornis newtoni*. *Memoirs of the Royal Society of South Australia* **1**(4): 111–126.

VICKERS-RICH, P. & MOLNAR, R. E. 1996. The foot of a bird from the Eocene Redbank Plains Formation of Queensland, Australia. *Alcheringa* **20**, 21–29.

WEBER, E. 1993. Zur Evolution basicranialer Gelenke bei Vögeln, insbesondere bei hühner- und Entenvögeln (Galloanseres). *Zeitschrift für Zoologische Systematiks und Evolutionsforschung* **31**: 300–317.

THREE NEW SPECIES OF *LEIOPATHES* (CNIDARIA: ANTHOZOA: ANTIPATHARIA) FROM SOUTHERN AUSTRALIA

DENNIS M. OPRESKO

OPRESKO, D. M. 1998. Three new species of *Leiopathes* (Cnidaria: Anthozoa: Antipatharia) from southern Australia. *Records of the South Australian Museum* **31**(1): 99–111.

Three new species of the antipatharian genus *Leiopathes* are described from the coastal waters of South and Western Australia and Tasmania. *Leiopathes secunda* sp. nov. is morphologically similar to *L. expansa* Johnson (1899) and *L. grimaldi* Roule (1905) but differs from those species in having larger and more numerous axial spines. *Leiopathes acanthophora* sp. nov. resembles *L. glaberrima* (Esper, 1788), but has larger spines which extend over a greater proportion of the corallum. *Leiopathes bullosa* sp. nov. is characterised by the distinctive hemispherical shape of its spines.

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Introduction

Very few studies have been conducted on the antipatharian fauna of Australia and Tasmania. In 1878 Studer reported on the antipatharians collected by the 'Gazelle' off West Australia and in the Mermaid Straits at depths of 45–50 fm. Two species were identified: *Antipathes foeniculum* Lamarck (= ?*A. foeniculacea* Pallas, 1766; according to Brook 1889) and *A. pinnatifida* Lamouroux, 1816. Brook (1889) suggested that *A. foeniculacea* might be related to *A. dichotoma* Pallas, 1766 and that *A. pinnatifida* might be identical with *A. ulex* Ellis and Solander, 1786. Both *A. foeniculum* and *A. pinnatifida* are poorly described and it is unlikely that either will ever be accurately identified.

Antipatharians are often inadvertently caught in the nets of fishermen. Such material is usually discarded: however, through the efforts of Karen Gowlett-Holmes and her associates, a large number of corals brought up by local fishermen trawling in the waters off the southern and western coasts of Australia and off Tasmania have been saved and carefully preserved. Among these corals were several specimens similar to species of *Leiopathes* found in the Atlantic and IndoPacific. Closer examination revealed species-specific differences in the morphology, size and density of the axial spines. Consequently, three new species are described. The holotypes and paratypes of the new species are deposited in the South Australian Museum (SAM), Adelaide, S. Australia; schizotypes (pieces of the holotypes or paratypes) of the specimens are deposited in the U.S. National Museum of Natural History (USNM) in Washington, DC.

Taxonomic Section

Order Antipatharia Milne Edwards, 1857

Family LEIOPATHIDAE Haeckel, 1896 (emended)

Diagnosis

Polyps with six primary and six secondary mesenteries. Primary (pm) and secondary mesenteries (sm) complete, attached to both inner wall of oral cone and actinopharynx. Secondary mesenteries located between transverse primary mesenteries (tpm) and sagittal primary mesenteries (spm); two on one side and four on opposite side of transverse axis, with one-half of each complement occurring on each side of sagittal axis; clockwise pattern described by sequence tpm-sm-spm-spm-sm-tpm-sm-sm-spm-spm-sm-sm. New polyps developing from coenenchymal surface between older polyps, as well as at distal end of branchlets.

Discussion

In 1896 Schultze proposed a reclassification of the Antipatharia based on the number of

mesenteries in the polyps. In this scheme the family Antipathidae was divided into three subfamilies, the Dodekamerota with 12 mesenteries, the Dekamerota with 10 mesenteries, and the Hexamerota with six mesenteries (these are invalid names according to the International Code of Zoological Nomenclature, Article 12). The Dodekamerota contained the single genus *Leiopathes*. Haeckel (1896, as cited in Carlgren 1908:134) was the first naturalist to treat the Dodekamerota as a suborder of the Antipatharia and to place *Leiopathes* in a separate family, using the name 'Liopathida'. This taxon, with the correctly emended name Leiopathidae, was subsequently recognized by Bourne (1900, as cited in Carlgren 1908:138), Roule (1905), and Hickson (1906). However, in his study of the Antipatharia of the 'Siboga' Expedition van Pesch (1914) discovered a species of *Cirrhipathes* (i.e., *C. contorta*) whose polyps also possessed six secondary mesenteries. This led van Pesch to conclude that the number of secondary mesenteries was not as significant a taxonomic character as Schultze had assumed. He therefore created a new taxon, the 'Heterotaeniales' to contain both the Dekamerota and the Dodekamerota. The 'Heterotaeniales' was treated by van Pesch as a subtribe of the Antipathidae and included all species with primary and secondary mesenteries, regardless of the number. In the last major revision of the order, Pax (1918) renamed the Heterotaeniales the 'Pleiomerota', and elevated the taxon to the rank of superfamily (the name was not based on a described genus). Within the Pleiomerota, Pax placed the families Antipathidae and Schizopathidae; *Leiopathes* was included in the Antipathidae.

The submergence of the Dodekamerota by van Pesch (1914) was based solely on his finding that *C. contorta* had six secondary mesenteries. However, van Pesch (1914) stated that the additional fifth and sixth secondary mesenteries in *C. contorta* are incomplete, meaning that they extend from the body wall but do not reach to the actinopharynx. In contrast, in *Leiopathes* all the secondary mesenteries are complete. Furthermore, according to van Pesch, the two incomplete mesenteries in *C. contorta* do not reach to the upper end of the oral cone nor do they occupy the same relative position as those in *Leiopathes*. In *C. contorta* they are located between the anterior secondary mesenteries and the primary sagittal mesenteries (van Pesch 1914), whereas in *Leiopathes* they occur between the anterior secondaries and the primary transverse ones (Brook 1889). These differences indicate that the two incomplete mesenteries in *C. contorta* are not homologous to those in *Leiopathes*. Consequently, *Leiopathes* can be viewed as a distinct and homogeneous group meriting recognition at a level above that of genus; therefore, the family Leiopathidae is reestablished here. Considering that the classification of the order has been substantially altered by the removal of the family *Dendrobrachiidae* to the Octocorallia (Opresko and Bayer 1991), the use of a distinct polyp-related character such as the number of mesenteries, seems appropriate for differentiating a family-level taxon. Further study may show that the Leiopathidae merits even higher taxonomic recognition.

Genus *Leiopathes* Haime, 1849

Leiopathes Gray, 1840:76 (nomen nudum); Gray, 1842:135 (nomen nudum); Haime, 1849:224 (type species *Antipathes glaberrima* Esper, 1792:160, pl. 9); Gray, 1857a:113; Gray, 1857b:273; Brook, 1889:95; Roule, 1905:73; Gravier, 1918:225.
Antipathes (in part), van Pesch, 1914:76; Pax, 1918:470.

Diagnosis

Corallum irregularly sympodial; branching multi-directional or flabellate. Branchlets arranged irregularly; loosely bilateral or uniserial; pinnules not present. Spines poorly developed; small, simple, smooth surfaced; conical, deltoid, or hemispherical in shape; reduced in size or absent on larger branches and stem. Polyps very variable in size and spacing; equally wide in sagittal and transverse diameters, or slightly longer along sagittal axis; uniserially arranged on smallest branches, irregularly distributed on all sides of axis on larger branches and stem.

Discussion

The type species of the genus is *Leiopathes glaberrima* (Esper, 1792). Esper's original specimen still exists in the Erlangen Museum in Germany, but was not available for study.

The genus name *Leiopathes* was first used by Gray in 1840 in a listing of the collections of the British Museum; however, the name was not accompanied by a description, illustration, or reference to a previously described species; therefore, it must be considered a nomen nudum. The name appears in subsequent editions of the Synopsis of the British Museum, but also without

a designated type species (Gray 1842). There is no evidence that Gray published a detailed description of *Leiopathes* until 1857. However, in 1849, in a publication describing a species he identified as *Leiopathes lamarcki*, Haime specifically stated that the type of *Leiopathes* was Esper's species *Antipathes glaberrima*. Even though he himself referred to *Leiopathes* as Gray's genus, Haime has to be considered the author of the genus.

In 1857 Gray reported that the species he had previously described in 1832 (as *Antipathes dichotoma*, Pallas) 'has been separated from others in the genus because the surface of the axis is smooth and not covered with a number of minute, uniform cylindrical spines like the true *Antipathes*' (Gray 1857a). In another paper appearing in the same year, Gray (1857b) defines the genus as follows: 'Axis smooth, polished, branched, forked. Bark soft, deciduous, deliquescent, sometimes forming (when dry) smooth, transparent masses at the fork of the branches'. It is in this second publication that Gray placed *Antipathes glaberrima* Esper in the genus *Leiopathes*, and he also indicated (in the synonymy) that *Antipathes dichotoma* Pallas was possibly identical to *L. glaberrima*. According to Brook, Lacaze Duthiers (1864, 1865) was the first investigator to observe that *L. glaberrima* possessed axial spines, and even though these spines are noticeable only on the smallest branches and branchlets, their presence essentially eliminated the primary character used by Gray. In 1889 Brook reported that the polyps of *L. glaberrima* possessed 12 complete mesenteries, not ten as in other species of the genus *Antipathes*, and for this reason he advocated that the genus be maintained. Therefore, *Leiopathes* is currently recognized not by the diagnostic characters given by Gray, but by the secondary description given by Brook. The illustration of *A. glaberrima* given by Esper (1792) indicates that the type is devoid of polyp tissue; therefore, it lacks the key diagnostic feature of the genus. Under such circumstances it would be appropriate to treat Brook's specimen as a substitute type specimen.

1. ***Leiopathes secunda*** sp. nov.
(Figs 1–3)

Diagnosis

Corallum branched irregularly, sympodial and flabellate to varying degrees; height 25 cm or more, with 30 or more orders of branching. Stem appearing crooked or sinuous. Smallest branchlets 5–10 mm long; commonly arranged uniserially, mostly 2–4 mm apart, on convex side of curved lower order branches; usually curved upward toward distal part of branch from which they arise. Groups of small branches and branchlets arranged in unilateral scorpioid cymes.

Spines simple, smooth, and conical with rounded or slightly acute apex; subequal or slightly unequal around axis circumference; typically 0.06–0.08 mm, but up to 0.12 mm, from midpoint of base to apex; and arranged in axial rows, generally with 5–6 spines per millimetre in each row. Spines present on stem; 0.06 mm tall.

Polyps very variable in size, up to 1 mm in transverse diameter (from proximal side of proximal lateral tentacles to distal side of distal lateral tentacles) and spaced up to 0.8 mm apart. Polyps on smallest branchlets arranged uniserially, usually with 6–8 polyps per centimetre.

Description of Holotype

The holotype (SAM H-756) is approximately 26 cm high and about 20 cm wide (Fig. 1), and the diameter of stem just above the basal end is 2.5 x 4.0 mm. The corallum is branched to the 30th order or more, with the higher order branches often becoming more developed than the branch from which they originate. As a result of this laxly sympodial branching, the stem and major branches have a crooked or sinuous appearance. Very few of the branches are longer than 5 cm and these often have 3–4 higher orders of branches. The branchlets (Fig. 2a) are often arranged uniserially, with up to 9 or more along a section of branch about 3 cm long. They usually occur on the convex side of the lower order branches; generally spaced 2–4 mm apart, with 3–4 branchlets per centimetre. The distal angle of the branchlets ranges from 60 to 90°, but most are close to 90°. Although a few of the branchlets are straight, most are curved toward the distal part of the branch from which they arise. Most of the largest unbranched branchlets on the corallum are 5–7 mm in length and 0.14–0.16 mm in diameter near their base (excluding spines); a few are as long 1.0 cm.

The spines on the branchlets (Fig. 3b) are generally 0.06–0.08 mm tall, as measured from middle of base to apex; a few are as large as 0.1 mm. They are simple, smooth and conical, and have a rounded or acute apex. The spines are equal or slightly unequal in size around the circumference of the axis. They are arranged in axial rows, 3–4 of which can be seen from one

FIGURE 1. *Leiopathes secunda* sp. nov., holotype, SAM H-756, entire corallum, height about 26 cm.

aspect (includes only those rows in which the base of the spines are visible), and within each row they are spaced 0.18–0.30 mm apart, resulting in 5–6 spines per millimetre in each row. At the tips of the branchlets the spines are relatively narrow with a more rounded apex, and the branchlet itself may be flanged with the spines occurring along ridges separated by shallow grooves (Fig. 3a). Spines are also present on the larger branches (Fig. 3c) and stem where they reach a maximum size of about 0.06 mm.

The polyps on the branchlets and higher-order branches are arranged somewhat uniserially, often on the convex or lateral side of the branchlets (Fig. 2b). In general, they tend to face out of one side of the corallum. Polyp size is very variable, but the largest polyps are usually not more than 0.8 mm in transverse diameter as measured from proximal side of proximal lateral tentacles to distal side of distal lateral tentacles. The interpolypar space is variable in width, up to about 0.8 mm. On average, there are 6–8 polyps per centimetre.

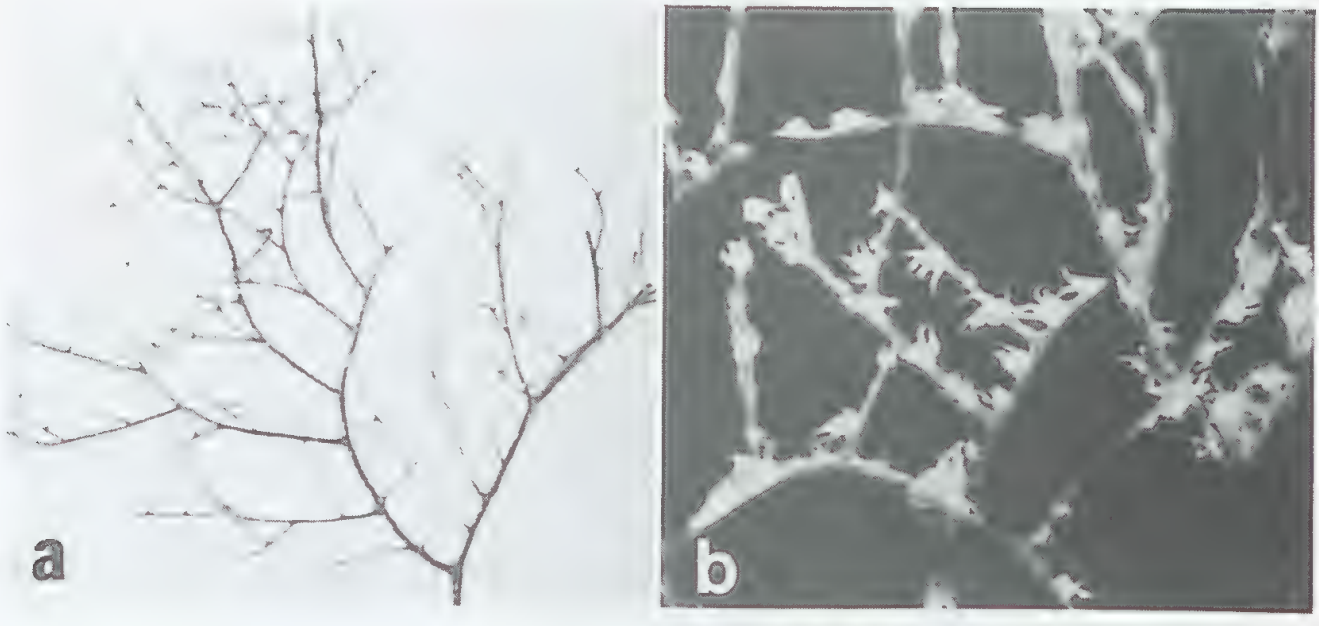

FIGURE 2. *Leiopathes secunda* sp. nov., holotype, SAM H-756; **(a)** outer edge of corallum showing the arrangement of the branchlets: **(b)** branchlets with polyps, approx. x 4.

Although the larger branches and stem are mostly denuded of soft tissues, where they are present, the polyps appear to be distributed on all sides of the axis.

Discussion

The paratypes are all small colonies; however, they each exhibit in varying degrees the distinctive uniserial branching pattern seen in the holotype. As in the holotype, the ultimate branchlets in these colonies are closely spaced and usually not more than 1 cm long. In one of the paratypes (SAM H-757) the spines on the branchlets attain a maximum size of 0.12 mm; in the others the

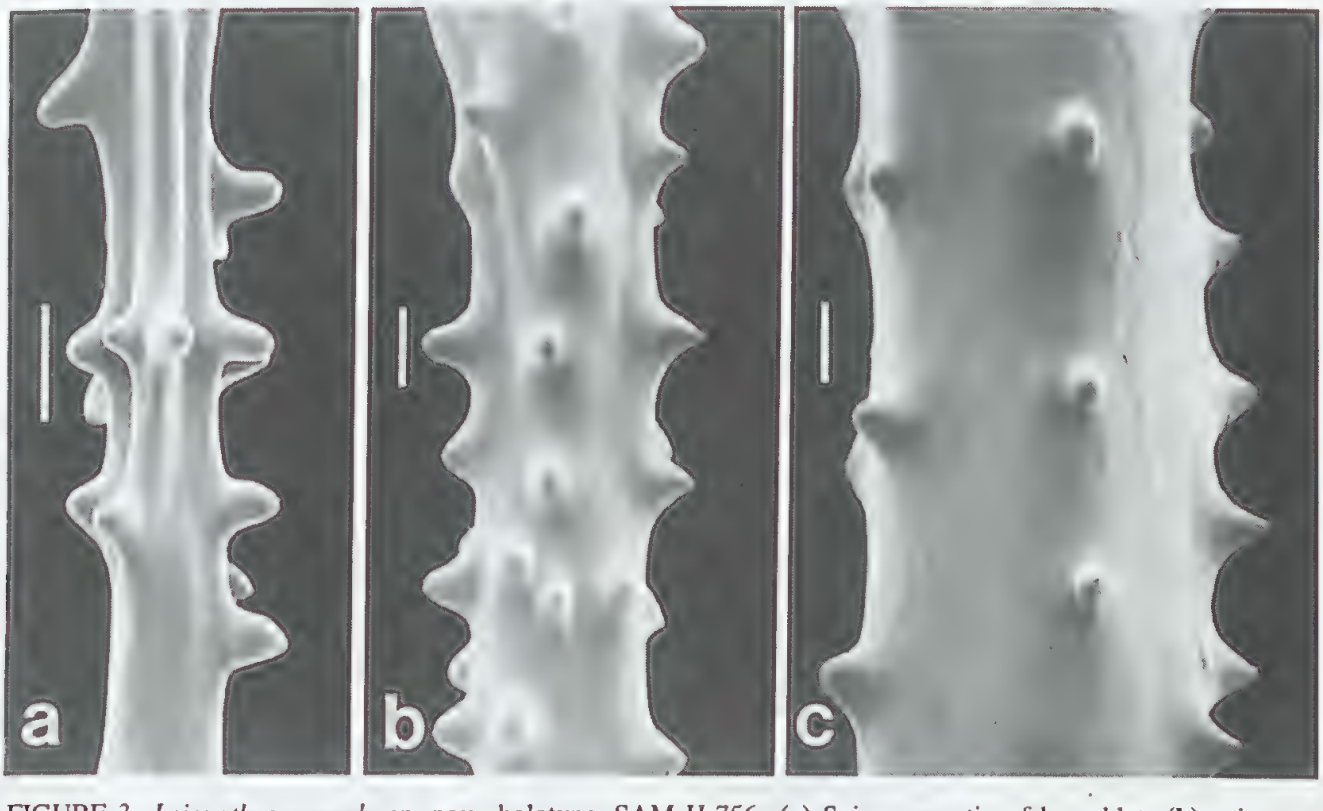

FIGURE 3. *Leiopathes secunda* sp. nov., holotype, SAM H-756; **(a)** Spines near tip of branchlet, **(b)** spines on branchlet 0.25 mm in diameter, **(c)** spines on branch 0.45 mm in diameter. Scale bars 0.1 mm.

largest spines are 0.06–0.08 mm. Slight variations occur among the specimens in the density and number of rows of spines (e.g., 3.5–7 spines per millimetre and 2–5 rows visible from one aspect), but such variability is likely to be observed even in a single specimen. Polyps in these specimens are usually 1 mm or less in transverse diameter. Although the interpolypar space is quite variable, there are generally 6–8 polyps per centimetre, as in the holotype.

Comparisons

In general appearance *Leiopathes secunda* sp. nov. resembles *L. expansa* Johnson, 1899 and *L. grimaldii* Roule, 1905. In both *L. expansa* and *L. grimaldii* the higher order branchlets are arranged uniserially on the convex side of the curved lower order branches, as in *L. secunda*. However, in *L. secunda* the branching is not as distinctly flabellate as in the other two species. Furthermore, the spines of *L. secunda* are slightly larger and more crowded than those of the other two species. Johnson (1899) described the spines of *L. expansa* as being minute, upright conico-subdeltoid, and irregularly scattered on the ultimate branchlets but absent on other parts of the corallum. As estimated from the illustration, the spines of *L. expansa* appear to be 0.05–0.06 mm tall and 0.5–0.6 mm apart on a branchlet 0.23 mm in diameter. In contrast, the spines of *L. secunda* are consistently 0.06–0.08 mm tall, with some reaching a size of 0.12 mm, and they are typically 0.14–0.30 mm apart. In addition, in *L. secunda* spines are also found on the largest branches and on the stem, whereas this is not the case in *L. expansa*. Roule (1905) does not mention the size of the spines of *L. grimaldii*, nor are any illustrations provided; however, he does note that they are only present on the smallest branchlets, i.e., branchlets measuring 0.2–0.3 mm in diameter.

Roule (1905) reported that the polyps of *L. grimaldii* are 0.5–1.0 mm in diameter and spaced 0.8–1.6 mm apart. The size and spacing of the polyps of *L. secunda* are similar. The polyps of *L. expansa* were not described by Johnson (1899) except for the statement that the specimen was a light red in color. Roule reported that the polyps and coensarc of *L. grimaldii* were red-yellow. The color of *L. secunda* was not recorded.

Etymology

From the Latin '*secunda*' (in a row) in reference to the uniserial arrangement of the branchlets.

Material Examined

Holotype. **Tasmania**: Cascade Plateau, about 160 nautical miles east of South East Cape, 44°00'S, 150°28'E, 760–910 m, F/V 'Labrador', 10 February 1990, K. Gowlett-Holmes (SAM H 756; schizoholotype, USNM 99407).

Paratypes. **Tasmania**: Cascade Plateau, about 160 nautical miles east of South East Cape, 43°58'S, 150°22'E, 890–900 m, F/V 'Labrador', 11 February 1990, K. Gowlett-Holmes (SAM H 757; schizoparatype, USNM 99404).—Cascade Plateau, about 155 Nm east of South East Cape, 43°58'S, 150°22'E, 1000 m, F/V 'Labrador', 9 February 1990, K. Gowlett-Holmes (SAM H 755; schizoparatype, USNM 99406).—Cascade Plateau, about 165 Nm east of South East Cape, 44°03'S, 150°26'E, 1100 m, F/V 'Labrador', 16 February 1990, K. Gowlett-Holmes (SAM H 758; schizoparatype, USNM 99398).

Distribution

Known only from the waters off Tasmania at depths of 760–1100 m.

2. ***Leiopathes acanthophora*** sp. nov.
(Figs 4–6)

Diagnosis

Corallum branched irregularly, but with some branches and branchlets uniplanar. Branchlets arising from all sides of lower order branches, but occasionally uniserial over short distances. Highest order, unbranched branchlets typically 1.5–2.5 cm long, 0.2–0.3 mm in diameter and spaced 5–7 mm apart.

Spines conical, acute, smooth, and subequal or slightly unequal. Spines on branchlets typically 0.10–0.14 mm from midpoint of base to apex. Spines on branchlets spaced 0.4–0.9 mm apart (2–3 per millimetre) and arranged in axial rows, 3–4 of which seen from one aspect. Spines present on larger branches and stem.

Polyps variable in size, 0.6–2.0 mm in transverse diameter and spaced 0.4–1.8 mm apart. Polyps on smallest branchlets arranged uniserially, with 4–6 polyps per centimetre. Polyps on larger branches occurring irregularly on all sides of axis.

Description of Holotype

The holotype (SAM H 906) consists of numerous broken pieces, one of which is about 30 cm tall (Fig. 4) and has a basal 'stem' diameter of about 5 mm. The largest simple branchlets (those on the outer edges of the corallum, Fig. 5a) are

FIGURE 4. *Leiopathes acanthophora* sp. nov., holotype, SAM H-906, entire corallum, height about 30 cm.

usually 1.5–2.5 cm long although some are as much as 4 cm long and 0.3 mm in diameter at their base. Branchlets are placed at very varying intervals, most commonly they are 5–7 mm apart, with 2–3 branchlets per centimetre. The distal branch angle is usually 90° or slightly less, and the terminal branchlets are straight or slightly curved.

The axial spines are 0.10–0.14 mm, as measured from the middle of the base to apex. They are simple, smooth, and conical, with a slightly rounded to acute apex. Those on the smallest branchlets (Fig. 6a) are relatively narrow with a rounded apex. On the larger branchlets they become more conical or deltoid (Fig. 6b). They measure 0.12 mm on a branch 0.8 mm in diameter (Fig. 6c), and 0.1 mm on a stem-like branch 4 mm in diameter. In places the size of the spines varies slightly (0.001–0.003 mm) around the circumference of the axis; however, the largest spines are not always associated with the polyp side of the axis. On the branchlets the spines are

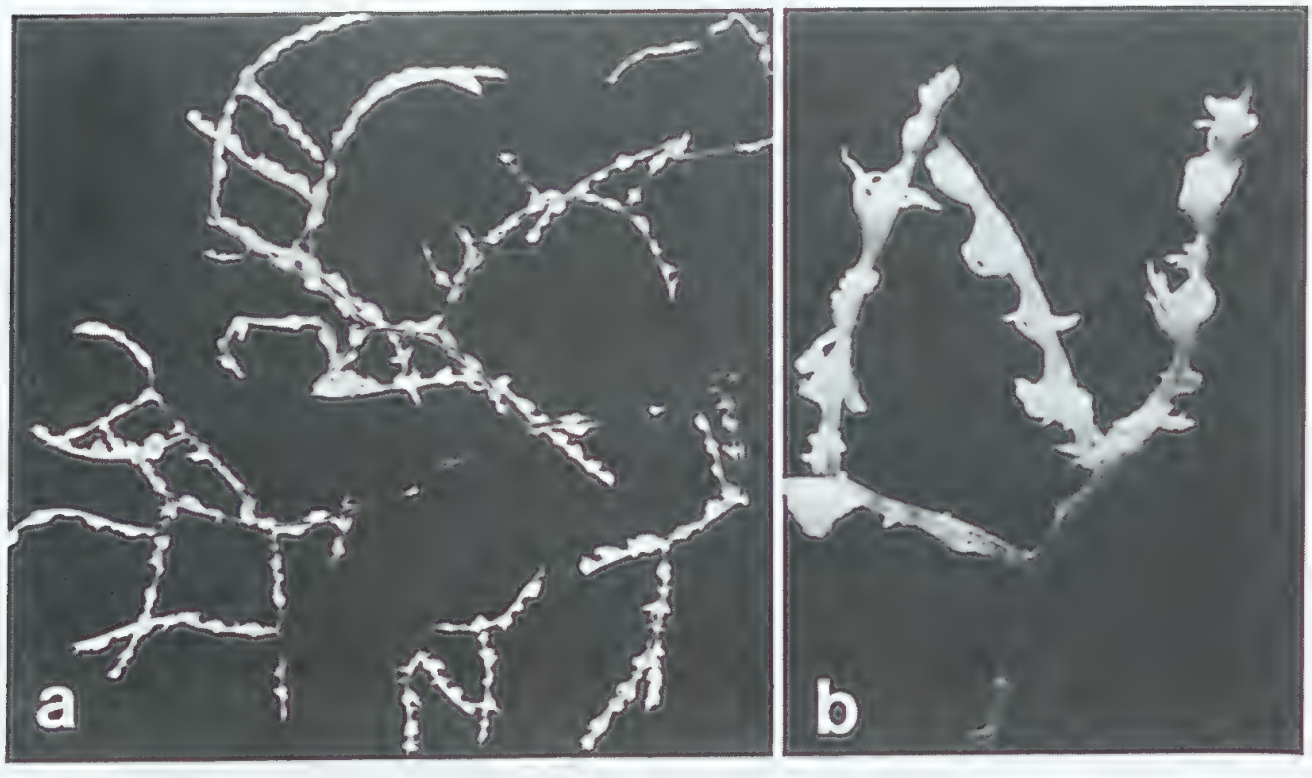

FIGURE 5. *Leiopathes acanthophora* sp. nov., holotype, SAM H-906; (a) outer edge of corallum showing arrangement of branchlets, (b) branchlets with polyps, approx. x 4.

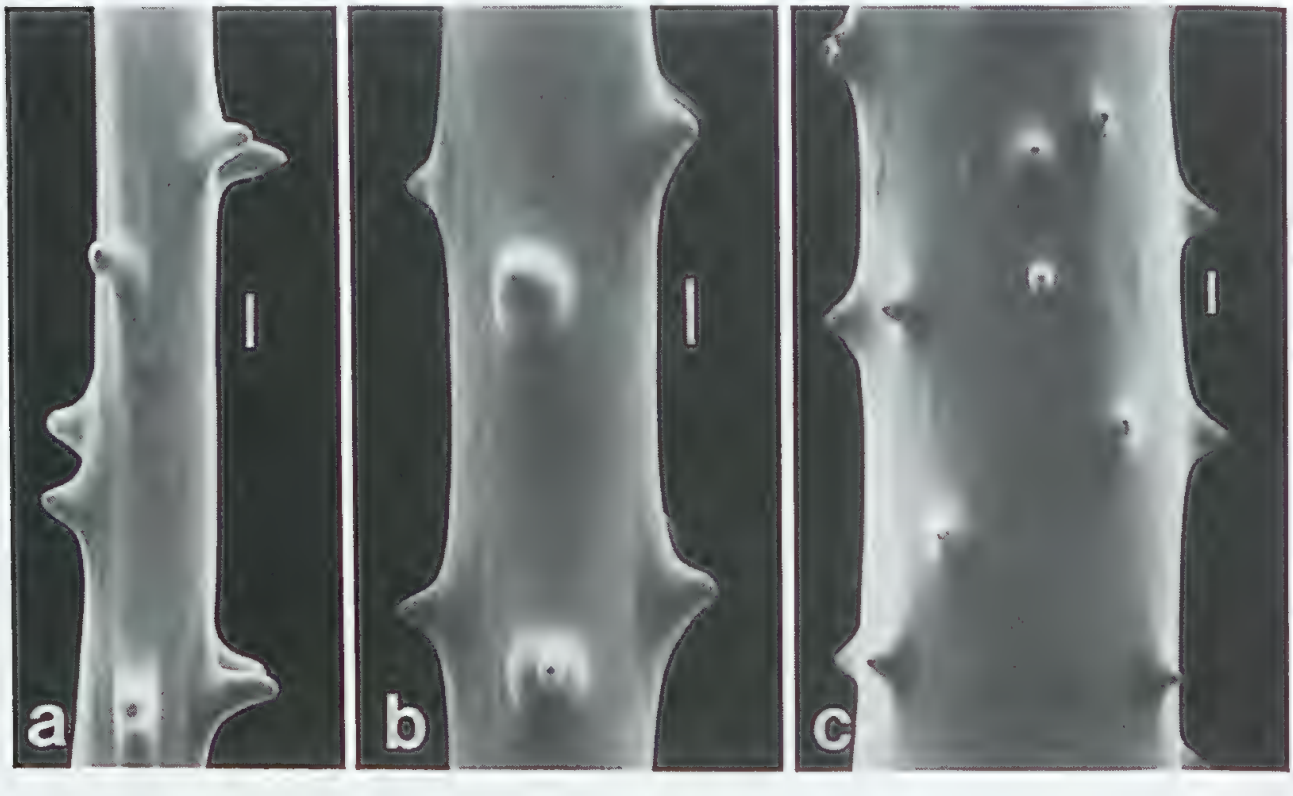

FIGURE 6. *Leiopathes acanthophora* sp. nov., holotype, SAM H-906; (a) Spines near tip of branchlet, 0.25 mm in diameter, (b) spines on branchlet 0.35 mm in diameter, (c) spines on branch 0.84 mm in diameter. Scale bars 0.1 mm.

arranged in axial rows, 3–4 of which can be seen from one aspect (includes only those rows in which the bases of the spines are visible); and within each row they are spaced 0.4–0.9 mm apart, resulting in 2–3 spines per millimetre. On the largest branches the spines tend to become flared out distally and proximally, and they are less regularly arranged in axial rows.

In general, the polyps are arranged uniserially (Figs 5a,b), although on the larger branches they occur irregularly on all sides of the axis. The size of individual polyps is quite variable, and small polyps are often present between the largest ones. In terms of transverse diameter, polyp size ranges from 0.6 to 2.0 mm (measured from proximal side of proximal lateral tentacles to the distal side of distal lateral tentacles). The interpolyp space is also quite variable, ranging from 0.4 to 1.8 mm; consequently, there can be as few as 4 to as many as 6 polyps per centimetre. In the alcohol-preserved material, the polyp tentacles measure 1.6–2.8 mm.

Comparisons

The branching pattern of *Leiopathes acanthophora* sp. nov. is similar to that of *L. glaberrima* (Esper, 1792). Both species have relatively long irregularly arranged branchlets. Based on descriptions given in the literature, it appears that the branchlets in *L. glaberrima* are thicker than those in *L. acanthophora*. Brook (1889) reported that the terminal branchlets in *L. glaberrima* were 0.5–0.7 mm in diameter, while those in *L. acanthophora* are only 0.2–0.3 mm. In addition, the spines of *L. acanthophora* are considerably larger than those in *L. glaberrima*. Based on the illustration given by Brook (1889), the spines in *L. glaberrima* measure 0.04–0.06 mm. In comparison, those in *L. acanthophora* are usually 0.10–14 mm. Furthermore, in *L. glaberrima* the largest branches are devoid of spines, but this is not the case in *L. acanthophora*. Brook (1889) also reported that the polyps in his specimen of *L. glaberrima* were about 1.0 mm in diameter. Although the polyps in *L. acanthophora* are quite variable in size, some are as much as 2 mm in diameter. These differences are sufficient to adequately differentiate the two species.

Etymology

From the Latin '*acantho*' (spine) and '*phora*' (bearing) in reference to the fact that this species has larger and more numerous spines than the closely related *L. glaberrima*.

Material Examined

Holotype. **Indian Ocean:** about 125 Nm east of Cape Arid, W. Australia, 34°03'S, 125°31'E, 1011–1020 m, F/V 'Adelaide-Pearle', 31 July 1988, K. Gowlett-Holmes, K. Olsson and M. Cameron (SAM H 906; schizoholotype, USNM 99402).

Distribution

Known only from off the coast of Western Australia, at a depth of 1011–1020 m.

3. ***Leiopathes bullosa*** sp. nov.
(Figs 7–9)

Diagnosis

Corallum branched irregularly, but with groups of branchlets tending to be uniplanar. Highest order, unbranched branchlets straight or curved slightly; up to 2 cm long, 0.2 mm in diameter and spaced 0.5–1.5 cm apart; with 1–3 branchlets per centimetre.

Spines typically hemispherical, blister-like; up to 0.14 mm from midpoint of base to apex, subequal or slightly unequal in size around the axis. Spines arranged in rows, commonly spaced 0.4–0.6 mm apart in each row, with 2.5–3.5 spines per millimetre. Spines absent on larger branches and stem.

Polyps 0.7–2.0 mm in transverse diameter, spaced 0.6–2.5 mm apart, with 3–5 per centimetre.

Description of Holotype

The holotype (SAM H-754) consists of a number of broken branches. One such piece is shown in Figure 7. The branching pattern is rather loose and open and generally does not follow any specific pattern, although on several branches the branchlets tend to be unilateral or bilateral, and the branching tends to be spread out in a single plane. The largest simple branchlets (those without secondary branching and usually located on the outer edges of the larger branches) are mostly 0.5–1.5 cm long and 0.10–0.15 mm in basal diameter (excluding spines); however, a few are as long as 2 cm and 0.2 mm thick. Branchlets are placed at very varying intervals, mostly 5–7 mm apart but up to 1.5 cm apart, usually with 2–3 branchlets per centimetre, but sometimes with only 1 per centimetre. The branchlets are inserted mostly at right angles (distal angle ~90°); they are usually straight or only slightly curved or sinuous (Fig. 8a).

FIGURE 7. *Leiopathes bullosa* sp. nov., piece of holotype, SAM H-754.

The spines are typically hemispherical and blister-like (Figs. 9c–d); although on the smaller branchlets they are more knob-like (Fig. 9b) and the axis can be fluted with the spines occurring along the edges of the ridges (Fig. 9a). The branchlet spines are very variable in size, 0.07–0.14 mm, as measured from middle of base to apex. They are subequal or slightly unequal in size with up to a 0.04 mm difference on opposite sides of the axis; the largest spines, however, are not consistently associated with the polyp side of the axis. The spines are arranged in axial rows, 3–4 of which can be seen from one aspect (includes only those rows in which the base of the spines are visible), and within each row they are spaced 0.2–0.7 mm apart (usually 0.4–0.6 mm). On average,

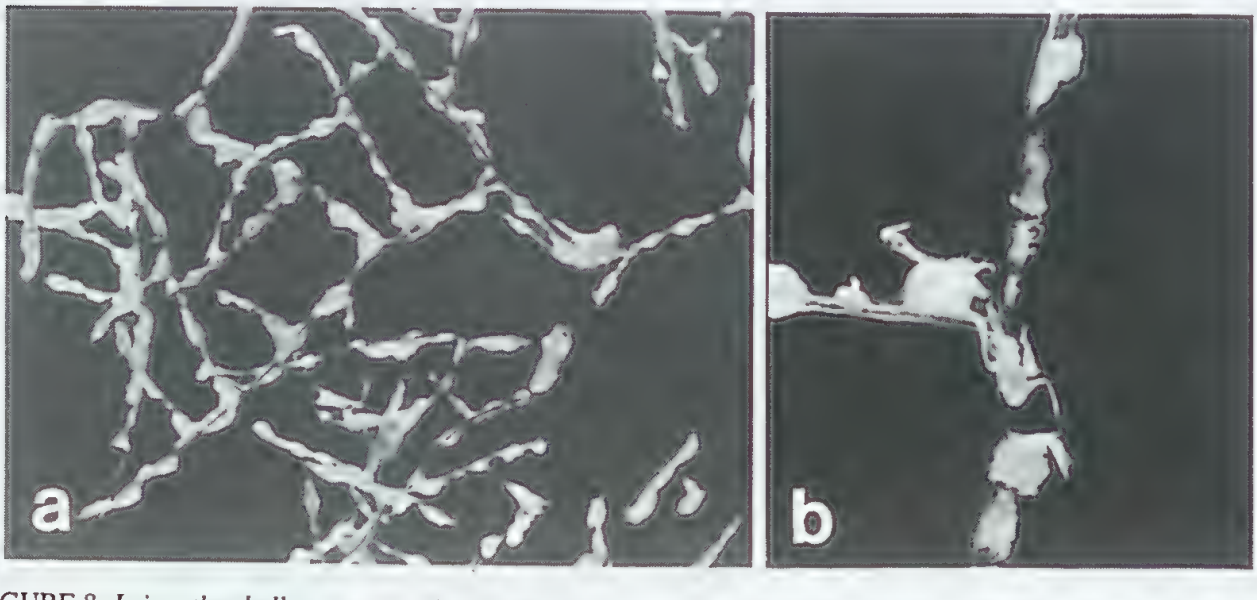

FIGURE 8. *Leiopathes bullosa* sp. nov., holotype, SAM H-754; **(a)** outer edge of corallum showing arrangement of branchlets, **(b)** branchlet with polyps, approx. x 3.5.

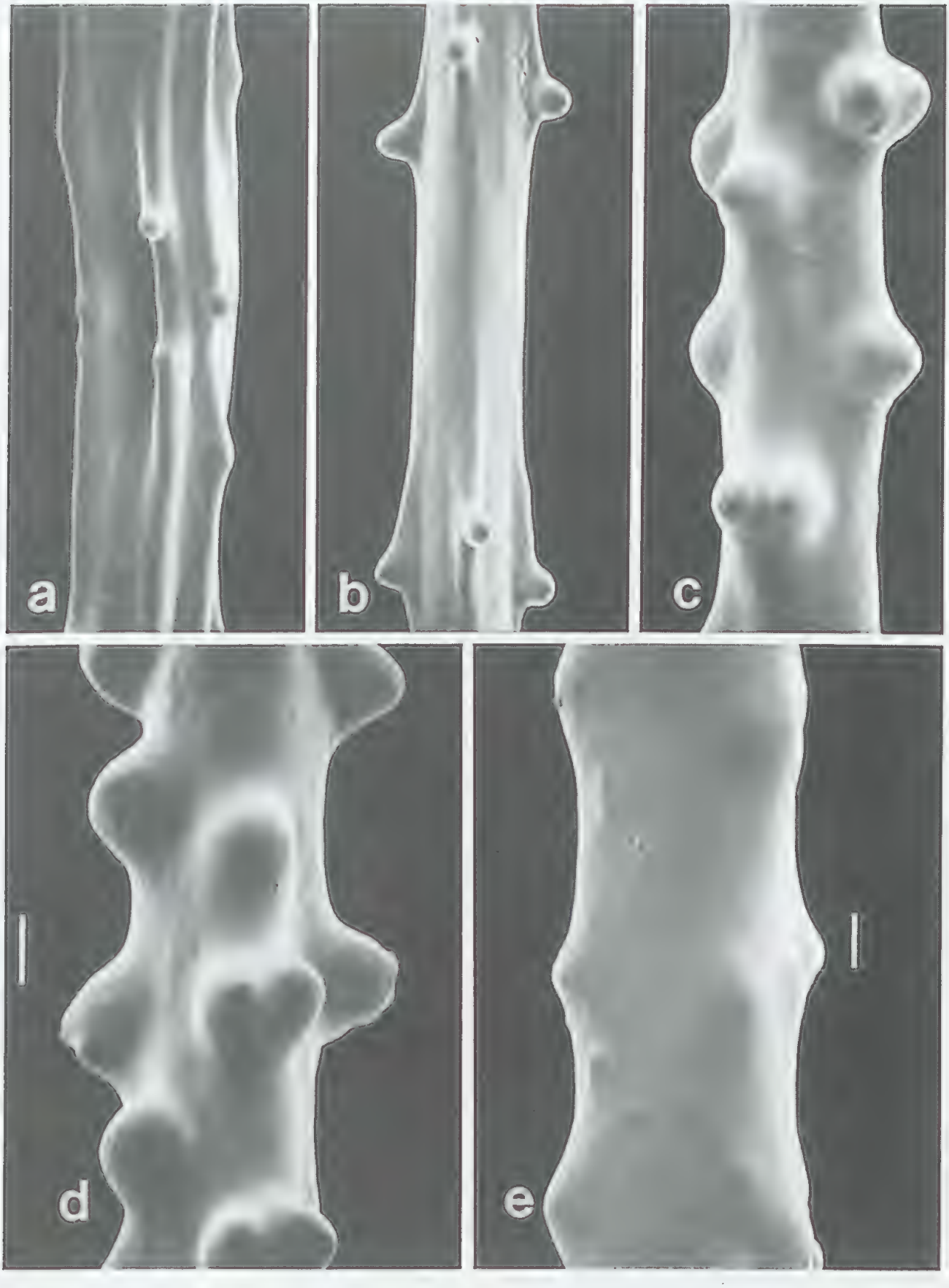

FIGURE 9. *Leiopathes bullosa* sp. nov., holotype, SAM H-754; **(a)** Spines on branchlet 0.2 mm in diameter, **(b)** spines near distal end of branchlet 0.15 mm in diameter, **(c)** spines on branchlet 0.28 mm in diameter, **(d)** spines on branchlet 0.27 mm in diameter, **(e)** branch 0.4 mm in diameter. Scale bars 0.1 mm; magnification in a and b as in d; in c as in e.

there are 2.5–3.5 spines per millimetre in each row. In places the spines can be seen to be undergoing longitudinal fission. On the larger branchlets and smallest branches the spines become wide and flattened, and on branches larger than 0.4–0.5 mm in diameter they are absent. However, the transition from hemispherical spines to no spines occurs in a very narrow and overlapping range of branch diameters, and sometimes smaller diameter branches may be smooth and larger ones spinous.

The polyps on the holotype are in a poor state of preservation (Fig. 8). They appear to be arranged uniserially on the branchlets and very irregularly on the largest branches. They are mostly 1.6–2.0 mm in transverse diameter as measured from proximal side of proximal lateral tentacles to distal side of distal lateral tentacles, but some are as small as 0.07 mm. The width of the interpolyp space is also variable, ranging from 0.6 to 2.5 mm. There appears to be 3–5 polyps per centimetre on the branchlets. The maximum length of the tentacles in the alcohol-preserved material is about 2.5 mm. The polyps were reported to be red in color when the specimen was collected.

Discussion

Leiopathes bullosa is unique among species of *Leiopathes*, as well as among other known species of antipatharians, in having hemispherical, blister-shaped spines. The development of a grooved and ridged axis on some of the smallest branchlets, which is also seen occasionally in *L. secunda* is an unusual feature resembling a similar structure present on the stems of certain species of *Bathypathes*.

Comparisons

In basic pattern of branching *Leiopathes bullosa* resembles *L. acanthophora* sp. nov. and *L. glaberrima* (Esper, 1792); however, the species can be differentiated by the size and shape of the spines which are very distinctly hemispherical in *L. bullosa* but deltoid in *L. glaberrima* and *L. acanthophora*. Although poorly preserved, the polyps on the type specimen of *L. bullosa* appear to be as large as those in *L. acanthophora*.

Etymology

From the Latin '*bullosa*' (covered with swellings) in reference to general appearance of the axis caused by the blister-like spines.

Material Examined

Holotype. **South Australia**: Great Australian Bight, about 120 Nm southwest of Cape Adieu, 33°29'S, 130°33'E, 520–560 m, F/V 'Longva', 14 April 1990, K. Gowlett-Holmes (SAM H-754; schizoholotype, USNM 99409).

Distribution

Only known from the Great Australian Bight, from a depth of 522–560 m.

Acknowledgments

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References

BOURNE, G. C. 1900. The Anthozoa. Pp. 1–80 *in* 'Treatise on Zoology', Part 2, Chapter 6, Ed. R. Lankester, London. (as cited in Carlgren 1908:138).

BROOK, G. 1889. Report on the Antipatharia. *Reports of the Scientific Results of the Voyage of the 'Challenger', Zoology* **32**: 1–222.

CARLGREN, O. 1908. Anthozoa. Pp. 134–138 *in* 'Bronn's Klassen und Ordnungen des Tier-Reichs', Vol. 2, Section 2, Parts 4–6. C.F. Winter'sche Verlagshandlung: Leipzig.

ELLIS, J. & SOLANDER, D. 1786. 'Natural History of Many Curious and Uncommon Zoophytes', London.

ESPER, E. J. C. 1792. 'Die Pflanzenthiere in Abbildungen nach der Natur mit Farben erleuchtet nebst Beschreibungen', Vol. 2, Pp. 133–164, Nürnberg.

GRAY, J. E. 1832. [No title]. *Proceedings of the Committee of Science and Correspondence of the Zoological Society of London*, March 29, 1832. Pp. 41–42.

GRAY, J. E. 1840. 'Synopsis of the contents of the British Museum', 42th ed., London.

GRAY, J. E. 1842. 'Synopsis of the contents of the British Museum', 44th ed., London.

GRAY, J. E. 1857a. On the animal and bark of *Antipathes*. *Proceedings of the Zoological Society of London*, 1857. P. 113.

GRAY, J. E. 1857b. Synopsis of the families and genera of axiferous zoophytes or barked corals. *Proceedings of the Zoological Society of London*, 1857. Pp. 273–294, 1 pl.

GRAVIER, C. J. 1918. Notes sur les Antipathaires du Golfe de Naples. Pubblicazioni della Stazione Zoologica di Napoli **2**: 229–240.

HAECKEL, E. 1896. 'Systematische Phylogenie der wirbellosen Tiere'. E. Reimer: Berlin (as cited in Carlgren 1908: 134).

HAIME, J. 1849. Sur le polypiéroïde d'un *Leiopathes glaberrima*. *Annales des Sciences Naturelles* **12**: 224–226.

HICKSON, S. J. 1906. Coelenterata: Anthozoa. Pp. 326–364 *in* 'The Cambridge Natural History', Vol. 1. Eds S. F. Harmer & A. E. Shipley. Macmillan & Co.: London.

JOHNSON, J. Y. 1899. Notes on the Antipatharian corals of Madeira, with descriptions of a new species and a new variety, and remarks on a specimen from the West-Indies in the British Museum. *Proceedings of the Zoological Society of London*, No. 53. Pp. 813–824.

LACAZE DUTHIERS, H. 1864. Mémoire sur les Antipathaires (genre *Gerardia*). *Annales des Sciences Naturelles (Zoologie)*, 5(2): 169–239 (as cited by Brook 1889).

LACAZE DUTHIERS, H. 1865. Deuxième mémoire sur les Antipathaires (*Antipathes* vrais). *Annales des Sciences Naturelles (Zoologie)*, 5(4): 5–61 (as cited by Brook 1889).

LAMOUROUX, J. V. F. 1816. 'Histoire Générale des Polypiers Coralligènes Flexibles'. Caen.

MILNE EDWARDS, H. 1857. 'Histoire Naturelle des Coralliaires'. Vol. 1. Paris.

OPRESKO, D. M. & BAYER, F. M. 1991. Rediscovery of the enigmatic coelenterate *Dendrobrachia* (Octocorallia: Gorgonacea), with descriptions of two new species. *Transactions of the Royal Society of South Australia* **115**: 1–19.

PALLAS, P. S. 1766. 'Elenchus Zoophytorum Sistens Generum Adumbrationes Generaliores et Specierum Cognitarum Succinctas Descriptiones cum Selectis Auctorum Synonymis'. Hagae-Comitum.

PAX, F. 1918. Die Antipatharien. *Zoologische Jahrbucher* **41**: 419–478.

ROULE, L. 1905. Description des Antipathaires et Cérianthaires Recueillis par S.A.S. le Prince de Monaco dans l'Atlantique Nord. *Résultats des Campagnes Scientifiques du Prince de Monaco*, Fasc. XXX. Monaco.

SCHULTZE, L. S. 1896. Beitrag zur Systematik der Antipatharien. *Abhandlungen der Senckenbergischen naturforschenden Gesellschaft* **23**: 1–40.

STUDER, T. 1878. 'Gazelle' Korallen, Abth. II, Anthozoa polyactinia. *Monatsberichte der Königlich Preussischer Akademie der Wissenschaften zu Berlin*, 1878 Pp. 524–550.

VAN PESCH, A. J. 1914. The Antipatharia of the 'Siboga' Expedition. *'Siboga' Expedition Reports*, Vol. 17. E.J. Brill: Leiden.

POOLOWANNA: A (H5) CHONDRITE FROM THE SIMPSON DESERT OF SOUTH AUSTRALIA

M. ZBIK & A. PRING

ZBIK, M. & PRING, A. 1998. Poolowanna: A (H5) chondrite from the Simpson Desert of South Australia. *Records of the South Australian Museum* **31**(1): 113–115.

The Poolowanna meteorite is a single stone weighing 0.875 kg and was found some 70 km west of the southern end of Lake Poolowana in north eastern South Australian. It consists of olivine ($Fa_{17.1\pm0.25}$, n=30), low-Ca pyroxene ($Fs_{17.6\pm1.7}$ $Wo_{0.7\pm0.8}$, n=25), and plagioclase feldspar. Based on texture and mineral chemistry, Poolowanna is classified as a H5 chondrite of shock stage S3–4.

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The meteorite was found in May 1997 by Mr Roger Henwood of Woomera, South Australia, during an expedition to the Simpson Desert to recover parts of the Blue-Streak Rocket which was launched from Woomera in 1966. Mr Henwood reported that he found the stone on the top portion of a wide sand dune in the Simpson Desert at a locality some 70 km west of the southern end of Poolowanna Lake, in northern South Australia. The locality is on the Poolowanna 1:250000 map sheet and the site was recorded using a GPS monitor (lat 26° 49.896'S, long 136° 51.523'E) (Figure 1). Given that there are few geographical place names in the Simpson desert we propose the name Poolowanna for the meteorite and should further meteorites be found in this map sheet area they be numbered sequentially. Mr Henwood surrendered the meteorite to the Museum in accordance with the South Australian Meteorite Act and was given a cash reward and presented with a bronze medallion to commemorate the find.

Macroscopic And Microscopic Description

The meteorite is 0.875 kg single stone, of rounded rectangular shape, measuring 12 x 9 x 4 cm, with a weathered brown fusion crust and a number of deep weathering cracks. The distinctive fusion crust is 1 to 2 mm thick and dark brown in colour due to the staining of iron oxide and hydroxide minerals. The silicate minerals throughout the meteorite are also stained by iron oxides and hydroxides, indicating that it had been exposed to the weather for many years. The fusion crust surface is broken by numerous fractures which have been filled with iron oxides and quartz grains.

In thin section, the meteorite is medium to fine-grained and generally stained brown by iron oxides. The chondrule boundaries are generally clearly visible but in areas of fracture and weathering the boundaries are sometimes obscured. The chondrules are typically between 0.5 and 1 mm in diameter but some of more than 2 mm in diameter were also noted. Metal and troilite have been partially oxidized and occur as disseminated grains (0.01–2.0 mm in longest dimension) throughout the matrix.

Sampling And Analytical Procedures

Polished thin sections were prepared from meteorite slices and were used for petrographic examination and microprobe analyses. Compositions of the silicate minerals were determined using a CAMECA SX51 electron microprobe with a Moran analysis package at the University of Adelaide Centre for Electron Microscopy and Microstructure Analysis. Analyses were made using an accelerating voltage of 15 kV, a sample current of 20 nA, and beam width of 5 μm.

Mineralogy

In the meteorite there are two groups of chondrules: those less than 1 mm in diameter are

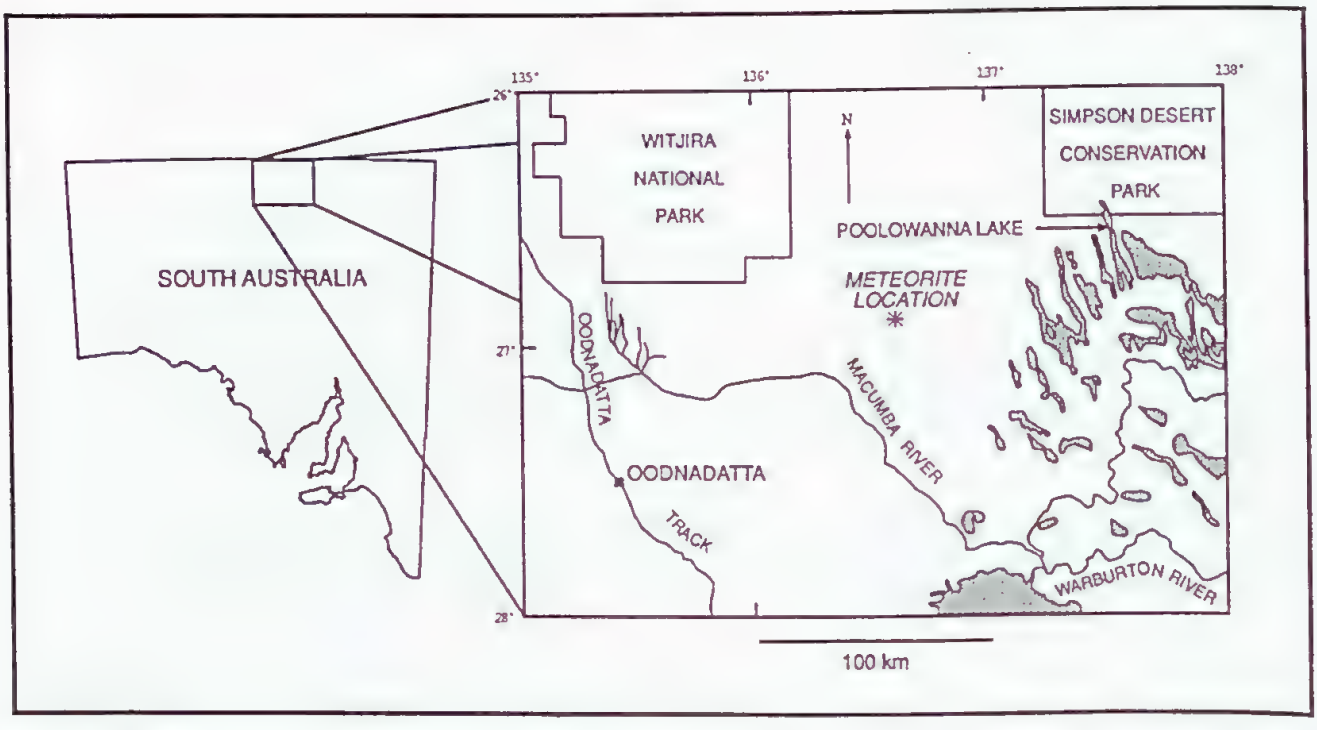

FIGURE 1. Map showing the location of the Poolowanna meteorite.

spherical while those larger are much less regular in shape. The chondrules and chondrule fragments are composed predominantly of recrystallised olivine and orthopyroxene and display microcrystalline texture. The chondrules can be classified according to the system of Wasson (1993). Barred olivine chondrules (BO) are rare and composed of olivine with pyroxene-plagioclase mesostasis between the olivine bars. There are a number of microcrystalline pyroxene chondrules (C) which range in size from a fraction of a millimetre to about 2 mm, and exhibit strong undulose extinction. Radial pyroxene chondrules (RP) are common, and display a range of crystal sizes but nucleation appears to have occurred at a single point on the rim of the chondrules. Several unusual chondrules, containing large radial pyroxene crystals coexisting with porphyritic olivine grains, were noted in Poolowanna. This type of chondrule is not included in Wasson's (1993) classification. A number of granular olivine-pyroxene chondrules (GOP), porphyritic pyroxene (PP) and pyroxene-olivine (POP) chondrules are also present. The latter contain fine and coarse, euhedral olivine grains and have a poikilitic texture with turbid microcrystalline plagioclase mesostasis between olivine and pyroxene crystals.

Olivine in the Poolowanna meteorite is equilibrated with a mean fayalite content of $Fa_{17.1\pm0.25}$, n=30. The orthopyroxene shows a limited variation in composition with a mean ferrosilite content of $Fs_{17.6\pm1.7}$, n=25 and a wollastonite content of 0.7 mol% ±0.8. Clinopyroxene has not been detected and the interstitial plagioclase is partially converted to maskelynite, and due to the heavy weathering of the meteorite its composition is variable and not original.

A number of quartz grains, almost certainly of aeolian origin, are incorporated into the weathered crust and introduced into the meteorite interior along fracture veins.

Classification

The Poolowanna meteorite is classified as an H5 chondrite. The olivine ($Fa_{17.1}$) and orthopyroxene ($Fs_{17.6\pm1.7}$) compositions are within the range of the H chondrites (Keil & Fredriksson 1964). The equilibrated mineral compositions, crystalline matrix, well-defined chondrule boundaries and recrystallised plagioclase, suggest that Poolowanna meteorite belongs to the type 5 classification of Van Schmus and Wood (1967). The wollastonite content in the orthopyroxene is similar to that found in other H5 chondrites (Scott *et al.*, 1986).

Pyroxene crystals in the Poolowanna chondrite

display weak planar fractures and weak mosaicism which all indicate that the meteorite seems to be only slightly shocked after metamorphism. According to the classification scheme of Stöffler *et al.* (1991), the shock facies is estimated to be S3–4; weakly to moderately shocked.

Acknowledgments

The authors wish to thank Mr Roger Henwood for bringing the meteorite to the Museum's attention, and Mr John Terrlet of CEMMA, University of Adelaide for assistance with electron microprobe analysis. We thank Dr Alex Bevan of the Western Australian Museum for his constructive review of this paper.

References

KEIL, K. & FREDRIKSSON, K. 1964. The iron, magnesium and calcium distribution in coexisting olivines and rhombic pyroxenes of chondrites. *Journal of Geophysical Research* **69:** 3487–3515.

SCOTT, E. R. D., TAYLOR, G. J. & KEIL, K. 1986. Accretion, metamorphism, and brecciation of ordinary chondrites: Evidence from petrologic studies of meteorites from Roosevelt County, New Mexico. *Proceedings of the Lunar and Planetary Science Conference* **17:** E115–E123.

STÖFFLER, D., KEIL, K. & SCOTT, E. R. D. 1991. Shock metamorphism of ordinary chondrites. *Geochimica. Cosmochimica. Acta.* **55:** 3845–3867.

WASSON, J. T. 1993 constraints on chondrule origins. *Meteoritics* **28:** 14–28.

VAN SCHMUS, W. R. & WOOD, J. A. 1967. A chemical-petrologic classification for the chondritic meteorites. *Geochimica Cosmochimica Acta* **31:** 747–765.

CONFIRMATION OF THE ASSOCIATION OF THE HYPERIIDEAN AMPHIPOD GENUS *HYPERIA* (CRUSTACEA: AMPHIPODA: HYPERIIDEA: HYPERIIDAE) WITH CTENOPHORES

In July 1993 several specimens of ctenophore (*Beroe* sp.) were observed in Port Phillip Bay, Victoria with a crustacean associate. One animal was collected and the associate removed and identified as the hyperiidean amphipod, *Hyperia gaudichaudii* Milne Edwards, 1840.

Species of *Hyperia* have been recorded in association with ctenophores of the genus *Beroe* in the literature previously (Thurston 1977) but Laval (1980) suspects that these records may actually be of *Hyperoche*, as young *Hyperoche* may have been confused with *Hyperia*. This would seem to be a reasonable assumption as *Hyperoche* is a well known associate of medusae and ctenophores (Flores & Brusca 1975, Harbison *et al.* 1977, Laval 1980) and some genera, and even families of hyperiideans, appear to be restricted to certain host groups (Laval 1980). Martin and Kuck (1991), in recording *Hyperia medusarum* from the giant scyphozoan, *Chrysaora achlyos* (see Martin *et al.* 1997), conclude that 'it is likely that species of *Hyperia* occur only on scyphozoan and hydrozoan medusae (Pasko 1987)'.

The present observation is based on only one collected animal although others were observed in the field by one of us (K. L. G-H). It was hoped that more material would be forthcoming but this has not occurred. Never-the-less, the association of *Hyperia* with ctenophores has now been confirmed and previous literature records of such associations should not be dismissed. *Hyperia galba* (Montague, 1815) has been recorded from *Beroe* by Stephensen (1923), Schellenberg (1942), Buchholz (1953) and Oldevig (1959) and *H. gaudichaudii* has been recorded from a large *Beroe* sp. from the Falkland Islands by Stebbing (1914).

Material examined

Host. *Beroe* sp. (SAM H912) approx. 40x25mm, from off Portsea, Port Phillip Bay, Victoria, drifting with current, 1–3m. Collected by K. L. Gowlett-Holmes, 5th July 1993. Photo index PH 0082, 3 colour slides.

Associate. *Hyperia gaudichaudii*, female 8.5mm with enlarged oostegites and eggs not yet released into brood pouch, with reddish pigment spots all over except for eyes and extremities of uropoda (SAM C5831). Photo index PC 0064 (same three slides as PH 0082).

The *Beroe* and its associate were transported alive to the South Australian Museum for observation.

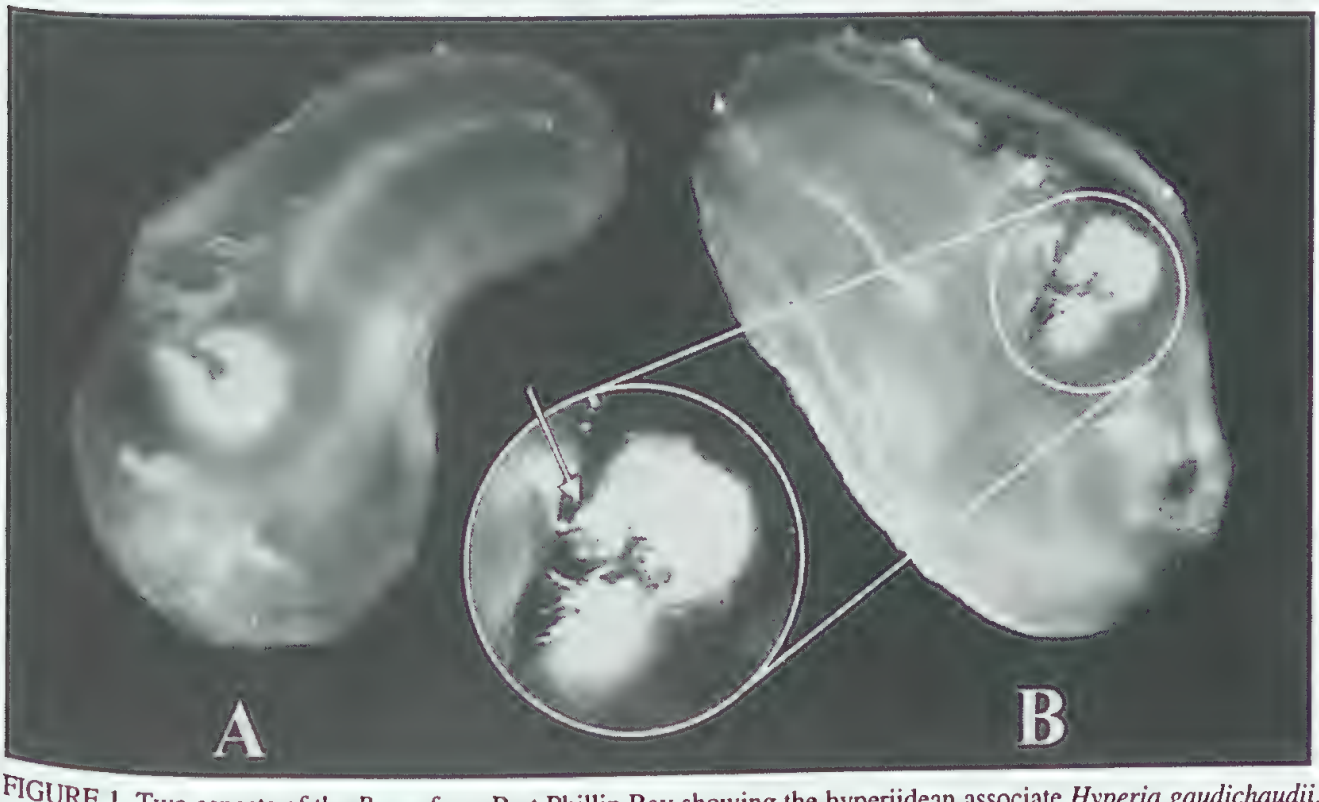

FIGURE 1. Two aspects of the *Beroe* from Port Phillip Bay showing the hyperiidean associate *Hyperia gaudichaudii*. The specimen on the right in B appears to be a male judging by the relatively long antennae (arrowed).

Field observations and location within host

Several *Beroe* (approx. 15) were observed in the field and at least half had hyperiidean associates. Generally two hyperiideans were observed together on each host, occupying the same cavity. When disturbed they became agitated and sometimes the smaller one or more slender specimen would flee. It is presumed that these were mating pairs and that it was the male, being 'free swimming,' that fled. When the specimen of *Beroe* being photographed was collected, one of the hyperiideans escaped. An examination of the slides taken of this animal (Fig. 1) revealed that one of the hyperiideans has relatively long antennae (Fig. 1B), confirming that it was a male that had escaped.

For the specimen collected, the female *Hyperia* was found in a small cavity along one of the comb rows (presumably created by the female) and was positioned upside down holding onto the *Beroe* tissues with pereopods 6 and 7. At the base of the cavity a flap of *Beroe* tissue separated the amphipod from a tunnel which went all the way through to the gastrovascular cavity, indicating that the amphipod either ventured to the gastrovascular cavity to feed or intended to provide access for her future offspring. Above this cavity, on the same comb row, an old scar with cilia missing indicated possible feeding. Similarly, on the comb row either side, shallow cavities with cilia missing suggest recent feeding or burrowing activities. It is also possible that these scars were made by other hyperiideans attempting to invade the same host but their proximity to the main cavity would suggest that the damage was made by the resident associate.

The kind of burrowing observed here, resulting in the combination of a cavity, tissue flap and tunnel to the gastrovascular cavity, has not been recorded previously for any other hyperiidean-gelatinous plankton association.

Actual feeding by the female *Hyperia* was not seen.

References

BUCHHOLZ, H. A. 1953. Die Wirtstiere des Amphipoden *Hyperia galba* in der Kieler Bucht. *Faunistische Mitteilungen aus Norddeutschland, Kiel* **1**(3): 5–6.

FLORES, M. & BRUSCA, G. J. 1975. Observations on two species of hyperiid amphipods associated with the ctenophore *Pleurobrachia bachei*. *Bulletin Southern California Academy of Sciences* **74**(1): 10–15.

HARBISON, G. R., BIGGS, D. C. & MADIN, L. P. 1977. The associations of Amphipoda Hyperiidea with gelatinous zooplankton – II. Associations with Cnidaria, Ctenophora and Radiolaria. *Deep – Sea Research* **24**: 465–488.

LAVAL, P. 1980. Hyperiid amphipods as crustacean parasitoids associated with gelatinous zooplankton. *Oceanography and Marine Biology, an Annual Review* **18**: 11–56.

MARTIN, J. W., GERSHWIN, L., BURNETT, J. W., CARGO, D. G. & BLOOM, D. A. 1997. *Chrysaora achlyos*, a remarkable new species of scyphozoan from the Eastern Pacific. *Biological Bulletin* **193**: 8–13.

MARTIN, J. W. & KUCK, H. G. 1991. Faunal associates of an undescribed species of *Chrysaora* (Cnidaria, Scyphozoa) in the Southern California Bight, with notes on unusual occurrences of other warm water species in the area. *Bulletin Southern California Academy of Sciences* **90**(3): 89–101.

OLDEVIG, H. 1959. Arctic, Subarctic and Scandinavian amphipods in the collections of the Swedish Natural History Museum in Stockholm. *Göteborgs Kungliga Vetenskaps - och Vitterhets - Samhälles Handlinger, Series* B **8**(2): 1–132.

PASKO, D. 1987. Host specificity and behaviour of *Hyperia medusarum* and *Hyperoche mediterranea* (Amphipoda: Hyperiidea): symbionts on gelatinous zooplankton. Unpublished MS thesis, Humboldt State University, 106pp.

SCHELLENBERG, A. 1942. Krebstiere oder Crustacea. IV. Flohkrebse oder Amphipoda. *Tierwelt Deutschlands* **40**: 1–252.

STEBBING, T. R. R. 1914. Crustacea from the Falkland Islands collected by Mr. Rupert Vallentin, F.L.S. – Part II. *Proceedings of the Zoological Society of London* **24**: 341–378.

STEPHENSEN, K. 1923. Crustacea Malacostraca, V. (Amphipoda. 1.) *Danish Ingolf - Expedition* **3**(8): 1–100, figs 1–22.

THURSTON, M. H. 1977. Depth distributions of *Hyperia spinigera* Bovallius, 1889 (Crustacea: Amphipoda) and medusae in the north Atlantic Ocean, with notes on the associations between *Hyperia* and coelenterates. Pp. 499–536 *in* 'A voyage of discovery: George Deacon 70th anniversary volume.' (Ed. M. Angel.) Pergamon Press Ltd. : Oxford.

Wolfgang ZEIDLER, South Australian Museum, North Terrace, Adelaide, 5000; Karen L. GOWLETT-HOLMES, CSIRO Division of Marine Research. GPO Box 1538 Hobart, 7001. *Records of the South Australian Museum* **31**(1): 117–118, 1998.

OBITUARY

MEREDITH JOAN SMITH

10 February 1943 – 18 July 1998

Friends and colleagues were shocked by the sudden death, on the 18 July 1998, of Dr Meredith Smith, aged 55 years, Senior Scientist in the Evolutionary Biology Unit of the South Australian Museum. Meredith had been on her first overseas holiday, on safari in Kenya, when three weeks into her trip she became ill. Tests in the hospital in Nairobi indicated that she had a very low haemoglobin count and after a blood transfusion Meredith returned to Australia with her eldest daughter Felicity. After further tests at the Royal Adelaide Hospital she was diagnosed with lymphoma. During a course of chemotherapy, Meredith died suddenly, two weeks after she had returned to Adelaide.

Born Meredith Joan Clark on 10 February, 1943, she attended the Magill Primary School and Norwood High School before entering the University of Adelaide in 1960. As a young woman, Meredith had wanted to become a vet, but this was not possible in South Australia so she chose zoology instead, gaining a First Class

Honours Degree in 1963. After working for two years with the CSIRO in Canberra, Meredith returned to Adelaide and completed a PhD thesis (Smith 1969) on the subject 'A study of the embryonic quiescence in diprotodont marsupials'. The excellence of her scientific work was recognised early in her career when, in 1968, she received the Bolliger Award from the Australian Mammal Society, for a paper titled 'Artificial termination of embryonic diapause in the red kangaroo and the tammar wallaby'.

While the intricacies of marsupial reproduction remained Meredith's scientific passion throughout her life, she somehow found the time to study fossil vertebrates from the Victoria Cave at Naracoorte, subfossil vertebrates from the Flinders Ranges as well as freshwater shrimps found in South Australian inland waters. Her early work focused on the reproduction of possums (Petauridae, Phalangeridae and Burramyidae) and kangaroos (Macropodidae), but later this was to change to the smaller rat-kangaroos (Potoroidae) and in particular the reproductive biology of the brush-tailed bettong *Bettongia penicillata*, which she was still studying just prior to her death.

In the early 1970s Meredith worked on the identification of small fossil vertebrates from Victoria Cave near Naracoorte in the South East of South Australia and became an acknowledged expert on the identification of a wide range of small vertebrates. From 1971 to 1976 she published five papers on the Naracoorte cave fauna with topics as diverse as the skull and dental characteristics of fossil Potoroidae, Petauridae, Burramyidae, Peramelidae, Thylacinidae, and Dasyuridae, to the identification of fossil birds and reptiles. Two papers concentrated on the identification of elapid snakes and lizards from the shape and measurement of their vertebrae (Smith 1975 & 1976). Two new species arose from Meredith's study of the Naracoorte fossils: a giant malleefowl *Progura naracoortensis* (van Tets & Smith 1974), and a giant primitive snake *Wonambi naracoortensis* (Smith 1976). Her interest in fossil snakes continued and in 1985 she described (Smith & Plane 1985) a new boid snake *Montypythonoides riversleighensis* from the World Heritage deposits at Riversleigh in Queensland.

A feature of her papers was the meticulous attention to detail. Descriptions of diagnostic characteristics and references were usually accompanied by drawings and/or photographs as well as tables of numerous measurements. Meredith's academic output was prodigious and during her scientific career she produced, or contributed to, two books on Australian mammals (Smith & Ganf 1980; Aslin, Smith & Ganf 1987), chapters for natural history books (Smith 1989a & 1996b), and species descriptions (Smith 1983, 1985, 1995), together with nearly 50 papers and a number of semi-popular articles. She was a member of the Australian Mammal Society and had edited the journal 'Australian Mammalogy' and the Bulletin in 1976. The list of her publications can be found at the end of this tribute.

In 1967 she married fellow student Murray Smith, and they had three children, Felicity, Tiffany and Matthew. After two years in Armidale, New South Wales, they returned to Adelaide and moved into their property at Norton Summit. Here they were able to cultivate fruit trees and Meredith kept a menagerie of animals, including a couple of horses, a pony, several donkeys as well as many bantams and ducks. She also bred sugar gliders and later brush-tailed bettongs. Meredith obtained part-time work as a demonstrator, first at Flinders University and later in the Zoology Department of the University of Adelaide.

It was here that I first met her in 1976. The meeting arose from my desire to learn more about the identification of the remains of small mammals found in owl pellets, which had been collected by some of my students during a Mawson High School field camp to Chambers Gorge in September 1975. In early October 1975, I forwarded this collection to Hans Mincham, then Information Officer at the South Australian Museum. As a result of Hans Mincham's report that the material contained rare and extinct species of rodents and small marsupials (identified by Meredith), many of which had never been found in the Flinders Ranges before, I returned to the site in May 1976. These collections, together with material collected by other individuals at Aroona Dam and Copley, prior to May 1974, formed the substance of a paper titled 'Remains of Mammals, including *Notomys longicaudatus* (Gould) (Rodentia: Muridae), in owl pellets from the Flinders Ranges, S.A.' published in *Australian Wildlife Research* in 1977. Here Meredith described for the first time the wealth of small mammals which had once populated the Flinders Ranges region. My interest aroused, I made six more trips to Chambers Gorge between September 1976 and October 1978 to determine the extent of the subfossil deposits in the central and eastern ends of the gorge. Meredith played a major role in helping to identify the material and to train me in its identification.

In May 1979 I invited Meredith, Murray and

their children to accompany me on a field trip to the eastern end of Chambers Gorge. The aim was to enable Meredith to see the Cave D site in the centre of Chambers Gorge, which had been the main source of old owl pellets for the 1977 paper, and to collect more pellets and bones. While Meredith and I excavated the floor of a new cave at the eastern end of the gorge, Murray took my two boys and his children to the old Moorowie Copper Mine. Here, he descended the rickety old wooden ladder (pre-1900 vintage) to the bottom of the shaft while the children waited at the surface. Our shallow excavation revealed the presence of a mat of grass, a wax match, parts of the page of a novel, part of a pamphlet referring to gunpowder and the lead of a large calibre bullet, indicating that the cave had once been used by miners. More interesting still, the cave also had evidence of occupation by stick-nest rats (*Leporillus* sp.), brushtail possums, ghost bats and barn owls. After this trip Meredith commenced to write a second paper on dasyurid remains found in the Chambers Gorge Cave D site as well as material from Big Moro Gorge and Top John Gorge north of Chambers Gorge. This paper (Smith & Medlin 1982) was presented by Meredith at a symposium on 'Carnivorous Marsupials' organised by the Royal Zoological Society of New South Wales, in May 1980.

Murray's death from bowel cancer in late 1980 was a devastating blow to Meredith, who was now left to manage the large Norton Summit property and to bring up three young children alone. To support her family and herself Meredith joined the Institute of Medical and Veterinary Science at Gilles Plains as an animal laboratory scientific officer, working part-time on the breeding biology and husbandry of Australian mammals, particularly marsupials. This department within the IMVS was transferred to the administration of the South Australian Museum in 1983 and became known as the Evolutionary Biology Unit (EBU). In November1983, Meredith presented a paper to the Australian Mammal Society's 'Possums and Gliders Symposium' held at the University of Armidale. Here, she described for the first time, the male and female reproductive systems and paracloacal glands of sugar gliders (*Petaurus breviceps*) and Leadbeater's possum (*Gymnobelideus leadbeateri*).

By the late 1980s her main research was centred on the breeding biology of *Bettongia* species and in particular the brush-tailed bettong (*Bettongia penicillata*). In 1992 the focus of EBU changed when it shifted from its location at Gilles Plains to the Division of Natural Science in the city, giving greater emphasis to molecular biology, and the live animal work was terminated. The loss of her beloved bettongs at Gilles Plains caused Meredith much grief, but she was able to retain a number of bettongs at home and to continue with her scientific work, while still working part-time at the South Australian Museum. Just before she left for Kenya, she was still studying the intricacies of the reproductive system of the brush-tailed bettong and had become very excited by a structure that she had recently dissected out from a female bettong.

Some additional tasks which formed part of Meredith's brief at the Museum included: management of the histology laboratory, advice to the Curator of Mammals on the identification of specimens in the mammal and subfossil collections, contributions to public programs and to review manuscripts as requested by scientific peers and editors in the CSIRO and tertiary institutions. Over the past 18 months, she had completed a paper on 'Establishment of a captive colony of *Bettongia tropica* by cross-fostering; and observations on reproduction' (Smith 1998) and was in the process of completing the description of a new species of extinct hopping-mouse from the Flinders Ranges. She had also completed the morphological analysis of the reproductive system and skeleton of a uniquely deformed kangaroo. Over the past two years she contributed to three public programs, viz. text for 'Nocturnal 1997', a unique exhibition by two artists of nocturnal animals; 'Extinctions SA' and 'Lost Fauna of Adelaide' where, as a key member of the team responsible for producing the exhibition, she provided captions and maps for extinct mammals on display.

Meredith occasionally participated in field work and during an earlier trip in June 1985 she visited Dalhousie Springs. This work resulted in a chapter on 'Mammals from the Dalhousie Springs Area, with Notes on some Reptiles and Frogs' in 'Natural History of Dalhousie Springs' by Zeidler and Ponder (1989). During 1997 she joined the Waterhouse Club expedition to the Flinders Ranges to share her expertise.

Outside of her scientific work, Meredith was able to continue her interest and love of animals. She was a member (and one-time secretary) of the S.A. Waterfowl Club Inc. and the S.A. Poultry Association and exhibited bantams and ducks of various breeds very successfully. In addition to keeping horses and

donkeys on her property at Norton Summit, Meredith was a long-time member of the Black Hill Pony Club.

A simple but moving service was held in St John's Anglican Church, Norton Summit with the eulogy being given by Meredith's aunt and Jacob Van Dissel from the pony club. In life, Meredith was a very private person and she probably would have been surprised at the number of her colleagues, friends, neighbours, and members of the above clubs, who came to the church to mourn her passing. This in itself was a measure of the esteem in which she was held. The funeral service was followed by a private cremation.

Meredith is survived by her mother, two daughters Felicity and Tiffany, and her son Matthew.

Acknowledgments

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Bibliography Of Meredith Joan Smith

1965:

Clark, M. J. & Sharman, G. B. 1965. Failure of hysterectomy to affect the ovarian cycle of the marsupial *Trichosurus vulpecula*. *Journal of Reproduction and Fertility* **10**: 459–461.

1966:

Clark, M. J. 1966. The blastocyst of the red kangaroo *Megaleia rufa* (Desmarest) during diapause. *Australian Journal of Zoology* **14**: 19–25.

1967:

Clark, M. J. & Poole, W. E. 1967. The reproductive system and embryonic diapause in the female grey kangaroo, *Macropus giganteus*. *Australian Journal of Zoology* **15**: 441–459.

Clark, M. J. 1967. Pregnancy in the lactating pygmy possum, *Cercartetus concinnus*. *Australian Journal of Zoology* **15**: 673–683.

Sharman, G. B. & Clark, M. J. 1967. The inhibition of ovulation by the corpus luteum in the red kangaroo, *Megaleia rufa*. *Journal of Reproduction and Fertility* **14**: 129–137.

1968:

Clark, M. J. 1968. Growth of pouch-young of the red kangaroo, *Megaleia rufa* in the pouches of foster mothers of the same species. *International Zoo Year Book* **8**: 102–106.

Clark, M. J. 1968. Termination of embryonic diapause in the red kangaroo, *Megaleia rufa*, by injection of progesterone or oestrogen. *Journal of Reproduction and Fertility* **15**: 347–356.

Smyth, M. and Smith, M. J. 1968. Obligatory sperm storage in the skink *Hemiergis peronii*. *Science* **161**: 575–576.

1969:

Smith, M. J., Brown, B. K. & Frith H. J. 1969. Breeding of the brush-tailed possum, *Trichosurus vulpecula* (Kerr), in New South Wales. *CSIRO Wildlife Research* **14**(2):181–193.

Smith, M. J. & Sharman, G. B. 1969. Development of dormant blastocysts induced by oestrogen in the ovariectomised marsupial *Macropus eugenii*. *Australian Journal of Biological Science* **22**: 171–180.

Smith, M. J. 1969. A study of the embryonic quiescence in diprotodont marsupials. PhD thesis, University of Adelaide.

1970:

Smith, M. J. & Godfrey, G. K. 1970. Ovulation induced by gonadotrophins in the marsupial, *Sminthopsis crassicaudata* (Gould). *Journal of Reproduction and Fertility* **22**: 41–47.

Smith, M. J. 1971. Breeding of the sugar glider *Petaurus breviceps* in captivity; and growth of pouch-young. *International Zoo Year Book* **11**: 26–28.

1971:

Smith, M. J. 1971. Small fossil vertebrates from Victoria Cave, Naracoorte, South Australia I. Potoroinae (Macropodidae), Petauridae & Burramyidae (Marsupialia). *Transactions of the Royal Society of South Australia* **95**: 185–198.

1972:

Smith, M. J. 1972. Small fossil vertebrates from Victoria Cave, Naracoorte, South Australia II. Peramelidae, Thylacinidae and Dasyuridae (Marsupialia). *Transactions of the Royal Society of South Australia* **96**(3): 125–137.

1973:

Smith, M. J. 1973. *Petaurus breviceps*. *Mammalian Species* **30**: 1–5. American Society of Mammalogists.

Smith, M. J. and How, R. A. 1973. Reproduction in the mountain possum, *Trichosurus cinus* (Ogilby), in captivity. *Australian Journal of Zoology* **21**: 321–329.

1974:

Smyth, M. & Smith, M. J. 1974. Aspects of the natural history of three Australian skinks, *Morethia boulengeri, Menetia greyii* and *Lerista bougainvillei*. *Journal of Herpetology 8*: 329–335.

van Tets, G. F. & Smith, M. J. 1974. Small fossil vertebrates from Victoria Cave, Naracoorte, South Australia III. Birds (Aves). *Transactions of the Royal Society of South Australia* **98**(4): 225–228.

1975:

Smith, M. J. 1975. The vertebrae of four Australian elapid snakes. *Transactions of the Royal Society of South Australia* **99**(2): 71–84.

1976:

Smith, M. J. 1976. Small fossil vertebrates from Victoria Cave, Naracoorte, South Australia IV. Reptiles. *Transactions of the Royal Society of South Australia* **100**(1): 39–51.

Smith, M. J. & Le Gay Brereton, J. 1976. Annual gonadal and adrenal cycles in the eastern rosella, *Platycercus eximius* (Psittaciformes: Platycercidae). *Australian Journal of Zoology* **24**: 541–5–546.

1977:

Hope, J. H., Lampert, R. J., Edmondson, E., Smith, M. J. & van Tets, G. F. 1977. Late Pleistocene faunal remains from Seton rock shelter, Kangaroo Island, South Australia. *Journal of Biogeography* **4**: 363–385.

Smith, M. J. 1977. Remains of mammals including *Notomys longicaudatus* (Gould) (Rodentia: Muridae), in owl pellets from the Flinders Ranges S.A. *Australian Wildlife Research* **4**: 159–170.

1978:

Smith, M. J., Bennett, J. H. & Chesson, C. M. 1978. Photoperiod and some other factors affecting reproduction in female *Sminthopsis crassicaudata* (Gould) (Marsupialia: Dasyuridae) in captivity. *Australian Journal of Zoology* **26**: 449–463.

1979:

Smith, M. J. 1979. Observations on the growth of *Petaurus breviceps* and *P. norfolcensis* (Marsupialia: Petauridae) in captivity. *Australian Wildlife Research* **6**: 141–150.

Smith, M. J., Hayman, D. L. & Hope, R. M. 1979. Observations on the chromosomes and reproductive systems of four macropodine interspecific hybrids (Marsupialia: Macropodidae). *Australian Journal of Zoology* **27**: 959–972.

Williams, W. D. & Smith, M. J. 1979. A taxonomic revision of Australian species of *Paratya* (Crustacea: Atyidae). *Australian Journal of Marine and Freshwater Research* **30**: 815–832.

1980:

Smith, M. J. & Ganf, R. W. 1980. 'Marsupials of Australia Volume 1. Possums, the Koala and Wombats'. Lansdowne Editions, East Melbourne.

Smith, M. J. & Williams, W. D. 1980. Infraspecific variation within the Atyidae: a study of morphological variation within a population of *Paratya australiensis* (Crustacea: Decapoda). *Australian Journal of Marine and Freshwater Research* **31**: 397–407.

1981:

Smith, M. J. 1981. Morphological observations on the diapausing blastocyst of some macropodid marsupials. *Journal of Reproduction and Fertility* **61**: 483–486.

Smith, M. J. & Rogers, P. A. W. 1981. Skulls of *Bettongia lesueur* (Mammalia: Macropodidae) from a cave in the Flinders Ranges, S.A. *Transactions of the Royal Society of South Australia* **105**: 217.

Smith, M. J. & Williams, W. D. 1981. The occurrence of *Antecaridina lauensis* (Edmondson) (Crustacea: Decapoda: Atyidae) in the Solomon Islands. An intriguing biogeographical problem. *Hydrobiologia* **85**: 49–58.

1982:

Bennett, J. H., Smith, M. J., Hope, R. M. & Chesson, C. M. 1982. Fat-tailed dunnart *Sminthopsis crassicaudata*: establishment and maintenance of a laboratory colony. Pp. 38–44 *in* 'The Management of Australian Mammals in Captivity'. Ed. D. D. Evans. The Zoological Board of Victoria, Melbourne.

Smith, M. J. 1982. Reptiles from the Late Pleistocene deposits on Kangaroo Island, South Australia. *Transactions of the Royal Society of South Australia* **106**(2): 61–66.

Smith, M. J. 1982. Whispers, screeches, gurgles, screams ... . *Australian Natural History* **20**(12): 413–418.

Smith, M. J. & Williams, W. D. 1982. Taxonomic revision of Australian species of *Atyoida*, (Randall) (Crustacea: Decapoda: Atyidae) with remarks on the taxonomy of the genera *Atyoida* and *Atya* (Leach). *Australian Journal of Marine and Freshwater Research* **33**: 343–361.

Smith, M. J. & Williams, W. D. 1982. Taxonomic revision of Australian genus *Caridinides*, (Calman) (Crustacea: Decapoda: Atyidae). *Australian Journal of Marine and Freshwater Research* **33**: 575–587.

Smith, M. J. & Medlin, G. C. 1982. Dasyurids of the northern Flinders Ranges before pastoral development. Pp. 563–572 *in* 'Carnivorous Marsupials' Vol. 2, ed. by M. Archer. Royal Zoological Society of N.S.W., Mosman.

1983:

Smith, M. J. 1983. A giant python from southern Australia, *Wonambi naracoortensis*. P.40 *in* 'Prehistoric Animals in Australia'. Eds. S. Quirk and M. Archer. Australian Museum, Sydney.

Smith, M. J. 1983. Koala. Vol. 8, 120–123 *in* 'The Australian Encyclopaedia'. The Grolier Society, Sydney.

Smith, M. J. 1983. Possums. Vol. 16, 34–35 *in* 'The Australian Encyclopaedia'. The Grolier Society, Sydney.

Smith, M. J. 1983. Western Pygmy-possum, *Cercartetus concinnus*. Pp. 162–163 *in* 'The Australian Museum Complete Book of Australian Mammals' ed. by R. Strahan. Angus & Robertson Publishers.

Smith, M. J. 1983. Desert Rat-kangaroo, *Caloprymnus campestris*. P. 192 *in* 'The Australian Museum Complete Book of Australian Mammals' ed. by R. Strahan. Angus & Robertson Publishers.

Smith, M. J. 1983. Tammar Wallaby, *Macropus eugenii*. Pp. 232–233 *in* 'The Australian Museum Complete Book of Australian Mammals' ed. by R. Strahan. Angus & Robertson Publishers.

Smith, M. J. 1983. Toolache Wallaby, *Macropus greyi*. P. 234 *in* 'The Australian Museum Complete Book of Australian Mammals' ed. by R. Strahan. Angus & Robertson Publishers.

Smith, M. J. & Williams, W. D. 1983. Reproduction cycles in some freshwater amphipods in southern Australia. Pp. 183–193 *in* 'Papers from a Conference on the Biology and Evolution of Crustacea' ed. by J. K. Lowry. *Memoirs of the Australian Museum* **18**.

1984:

Smith, M. J. 1984. The reproductive system and paracloacal glands of *Petaurus breviceps* and *Gymnobelideus leadbeateri* (Marsupialia: Petauridae). Pp. 321–330 *in* 'Possums and Gliders' ed. by A. P. Smith and I. D. Hume. Surrey Beatty & Sons and the Australian Mammal Society: Sydney.

Smith, M. J. 1984. Observations on the reproductive system and paracloacal glands of *Cercartetus lepidus* (Marsupialia: Burramyidae). *Australian Mammalogy* **7**: 175–178.

1985:

Smith, M. J. 1985. *Wonambi naracoortensis*. The Giant Australian Python. Pp. 156–159 *in* 'Kadimakara: Extinct Vertebrates of Australia'. Eds. P. V. Rich, G. F. van Tets and F. Knight. Pioneer Design Studio, Lilydale.

Smith, M. J. & Plane, M. 1985. Pythonine snakes (Boidae) from the Miocene of Australia. *BMR Journal of Australian Geology and Geophysics* **9**: 191–195.

1987:

Aslin, H. J., Smith, M. J. & Ganf, R. W. 1987. 'Marsupials of Australia Volume 2. Carnivorous Marsupials and Bandicoots'. Lansdowne Editions, Chatswood NSW.

1989:

Smith, M. J. 1989a. Mammals from the Dalhousie Springs area, with some notes on reptiles and frogs. Pp. 119–21 *in* 'Natural History of Dalhousie Springs' ed. by W. Zeidler, and W. F. Ponder. South Australian Museum, Adelaide.

Smith, M. J. 1989b. Release of embryonic diapause in the Brush-tailed Bettong, *Bettongia penicillata*. Pp. 317–321 *in* 'Kangaroos, Wallabies and Rat-kangaroos'. Ed. by G. Grigg, P. Jarman, and I. Hume. Surrey Beatty & Sons: Sydney.

1990:

Hayman, D. L., Smith, M. J. & Rodger, J. C. 1990. A comparative study of chiasmata in male and female *Bettongia penicillata* (Marsupialia). *Genetica* **83**: 45–49.

1992:

Hinds, L. A. & Smith, M. J. 1992. Evidence from plasma progesterone concentrations for male-induced ovulation in the brush-tailed bettong *Bettongia penicillata*. *Journal of Reproduction and Fertility* **95**: 291–302.

Smith, M. J. 1992. Evidence from the oestrous cycle for male-induced ovulation in *Bettongia penicillata* (Marsupialia). *Journal of Reproduction and Fertility* **95**: 283–289.

1994:

Merchant, J. C., Libke, J. A. & Smith, M. J. 1994. Lactation energetics of growth in the brush-tailed bettong *Bettongia penicillata* (Marsupialia: Potoroidae) in captivity. *Australian Journal of Zoology* **42**: 267–277.

Smith, M. J. 1994. Male-induced oestrus and ovulation in female brush-tailed bettongs (*Bettongia penicillata*) suckling a young in the pouch. *Reproduction, Fertility and Development* **6**: 445–449.

1995:

Smith, M. J. & Hinds, L. 1995. The Tammar Wallaby *Macropus eugenii* (Desmarest 1817). Pp. 329–331 *in* 'The Mammals of Australia', ed. by R. Strahan. Reed Books, Chatswood.

Smith, M. J. 1995. Western Pygmy-possum *Cercartetus lepidus* (Thomas 1888). Pp. 213–214 *in* 'The Mammals of Australia', ed. by R. Strahan. Reed Books, Chatswood

Smith, M. J. 1995. The Desert Rat-kangaroo *Caloprymnus campestris* (Gould 1843). Pp. 296–297 *in* 'The Mammals of Australia', ed. by R. Strahan. Reed Books, Chatswood.

Smith, M. J. 1995. Toolache Wallaby *Macropus greyi* (Waterhouse 1845). Pp. 339–340 *in* 'The Mammals of Australia', ed. by R. Strahan. Reed Books, Chatswood.

1996:

Smith, M. J. 1996a. Duration of embryonic diapause in the brush-tailed bettong, *Bettongia penicillata* (Potoroidae): effect of age on quiescent corpus luteum. *Reproduction, Fertility and Development* **8**: 807–810.

Smith, M. J. 1996b. Mammals of the Flinders Ranges. Pp. 127–131 *in* 'Natural History of the Flinders Ranges' ed. by M. Davies C. R. Twidale and M. J. Tyler. Royal Society of South Australia: Adelaide.

1998:

Smith, M. J. 1998. Establishment of a captive colony of *Bettongia tropica* (Marsupialia: Potoroidae) by cross-fostering; and observations on reproduction. *Journal of Zoology, London* **244**: 43–50.

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MUSEUM VICTORIA
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THE EGYPTIAN COLUMN AT THE SOUTH AUSTRALIAN MUSEUM

MICHAEL O'DONOGHUE

O'DONOGHUE, M. 1999. The Egyptian Column at the South Australian Museum. *Records of the South Australian Museum* 31(2): 127–147.

It is nearly a century since the Egyptian Column was erected in the forecourt of the South Australian Museum. This article provides a description of the column, an account of its archaeological discovery in the temple of the god Herishef at Heracleopolis, the history of its coming to Adelaide and a translation of its hieroglyphic inscription.

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Introduction

On 7 July 1999, the Egyptian column will have graced the lawns in front of the South Australian Museum for a century (Figure 1). It has become a cultural landmark in Adelaide with generations of South Australians and visitors to the state wandering past it and wondering at the civilisation which gave it birth. The possession of such a column is a distinction which the South Australian Museum shares with only a handful of museums around the world.

Information about the column exists in a number of places including the original archaeological reports and the archives of the Museum but this information has never been brought together and published. Alan Rowe in his manuscript 'A Guide to the Egyptian Antiquities in the South Australian Museum' (1920), discussed the column at length, but he was not aware of William Matthew Flinders Petrie's work (Petrie 1905) and his manuscript was never published. The purpose of this article is to describe the column and its original and modern contexts as fully as possible. To do so I will survey the history of the column, its origins, its location in the portico of the temple of Herishef, its archaeological discovery and its donation to the South Australian Museum. I shall also translate the hieroglyphic texts it carries.

Description

The column was carved from a single piece of granite which came from Aswan in upper Egypt. When discovered it was in two pieces and the mend can be clearly seen in the middle register. Its capital was also missing. A replica of the capital was carved in Adelaide of Murray Bridge granite using a cast of a capital from a matching column which was supplied from the British Museum. The capital consists of an abacus supported by nine palm fronds. At the base of the fronds a number of circular bands have been

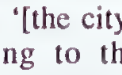
FIGURE 1. The Egyptian Column in the forecourt of the South Australian Museum. Photograph: South Australian Museum Photographic Library.

FIGURE 2. Map of Egypt showing location of Ihnasya el-Medina (Heracleopolis on map). Note the location of Aswan, the source of the granite for the column. From James 1988:8, copyright Trustees of the British Museum, British Museum Press.

carved. Below these is the shaft which has a slight narrowing towards the top. The intention is to represent a palm tree and it may be compared with the real palms planted around it in its present location on the museum lawns. Ramesses II made use of the smooth shaft to inscribe his name and titles in vertical columns, together with scenes of him offering burning incense to the god Herishef. His son Merneptah began to add his own names, and these can be seen as very faint traces between the vertical columns of Ramesses in the lowest register. The base of the column is of local construction.

According to Petrie (1905: 14) the diameter of the column is 29.9 inches (75.8 cms) at its base, and 25.1 inches (63.6 cms) at the top of the shaft. The height of the shaft from the base to the bottom of the bands at the top of the shaft is 142 inches (360.5 cms). The bands, palm fronds and abacus are the local reconstruction.

Ihnasya-El-Medina

The column comes from the temple of the god Herishef in the Egyptian town which bears the modern Arabic name of Ihnasya el-Medina and which was known during the Greco-Roman period in Egypt as Heracleopolis Magna. Its ancient Egyptian name was Nen-neswet (*Nn-nswt* ), which means '[the city] of the Royal Child', perhaps referring to the god Horus (Mokhtar 1983: 62f). As the map (Figure 2) shows, this site is in middle Egypt about 120 kms south of Cairo, just south of the entrance to the Faiyum depression. It stands about 10 kms to the west of the Nile and on the east bank of the large canal now called the Bahr Yussef which, after flowing from the Nile and running parallel to it, eventually flows into the Faiyum.

The ancient site of Heracleopolis is represented by a series of mounds which encompass the modern town of Ihnasya el-Medina from the west and south-west (Mokhtar 1983: 71). Over time the mounds have been partially excavated in search of monuments, *sebakh* (the valuable fertiliser which is the result of the manufacture of ancient bricks from Nile mud and straw) and limestone. Little is now to be seen on the surface.

The earliest mention of the city in Egyptian texts is from the 5th Dynasty (c.2498–2345 BCE)[1] during the Old Kingdom. In the First Intermediate Period (9th and 10th Dynasties 2160–2040 BCE), when central authority in Egypt was weakened, the rulers of Heracleopolis claimed to be rulers of all Egypt. From the Middle Kingdom onwards the city was clearly important and is frequently mentioned in the Egyptian texts. The nearby necropolis of Sedment seems to have been the burial ground for the ancient city and tombs have been found there from most eras in Egyptian history (Mokhtar 1983: 100ff).

The city was called by the Greeks, and then by the Romans, Heracleopolis Magna. Heracleopolis means 'the city of Herakles' and it seems to have been so named because the Greeks identified their god Herakles with the Egyptian God of the locality, Herishef. *Magna* means 'great' to distinguish it from another city with the same name which was given the designation *Parva* 'small'.

Heracleopolis Magna is mentioned by several classical authors writing on Egypt. Strabo (*Geographia* Book XVII 1.39), who spent a number of years in Egypt following a journey up the Nile in 25–24 BCE, and Pliny (*Natural History*, Lib. V: 9–4, 11) (23–79 CE) both mention it as an important city in Egypt. These and other references over the next centuries reflect its importance in Greco-Roman and Christian Egypt.

Excavation Of The Temple

The site was first excavated by Edouard Naville for the Egypt Exploration Fund in 1891. His account, published in 1894, was rather sketchy (Naville 1894) but he must be credited with the discovery of the site of the New Kingdom temple of Herishef and with the conclusion that it could be traced back to the Twelfth Dynasty (1991–1782 BCE). The area of the archaeological site is huge and Naville admitted that it was pure chance that he found the site of the temple of Arsaphes, as he called Herishef. He made several soundings until about five metres below the modern surface he hit upon a column capital and dug all around it:

> We thus cleared what I believe to be all that is still extant of the great temple of Arsaphes. It is a rectangular hall, in the forepart of which is a row of six granite columns (Naville 1894: 9).

This seems to refer to what Petrie (1905) was to

[1] Scholars have adopted the less Euro-centric convention of using BCE (Before Common Era) and CE (Common Era) in place of BC and AD but the year numbering remains the same.

call the portico with its columns (section II in Figure 8). The Adelaide column is one of these. To clear what Naville thought was the temple required the removal of over 40 000 cubic metres of earth. He recorded that only one of the columns was perfect. It is now in the British museum. Inscriptions on both sides of the doorway behind the row of columns, which gave access to the inner courts of the temple, recorded that the monument was erected by Ramesses II to his father Herishef. Naville found sections of the architrave, which had been reused, with the name of Senusert II still discernible. Since he was a pharaoh of the Middle Kingdom, Naville concluded that an original Twelfth Dynasty temple stood on the site, although he could not identify any of its plan. He also discovered the bases of a colonnade beyond the vestibule and a very well preserved, though broken in two, statue of Ramesses II with much of the original colour still in evidence.

Unfortunately Naville did not publish any plan of the discoveries and so the three photos he included become vital for restoring the original location of the finds. The photos show the positions of the columns when excavated, including the one which was to end up in Adelaide (Naville 1894: Frontispiece and Plates V, VI).

Naville must have immediately arranged the removal of the columns, presumably to England, from where they were rapidly distributed around the world. The Adelaide column was offered to the South Australian Museum late in 1891 (Amelia Edwards' letter dated November 1891, State Records of South Australia GRG 19, Series 58), the same year it was discovered. This hasty removal and the lack of any plan of the site were to cause problems for the next excavator.

In 1904 Petrie also excavated at Ihnasya. On the basis of his re-excavation on a more extensive scale, Petrie reconstructed the history of the temple (Petrie 1905). He concluded that in the Twelfth Dynasty (1991–1782 BCE) a smaller temple had been erected, probably by Senusert II and Senusert III, since their cartouches appear on blocks which were reused in later reconstructions of the temple. Petrie also suggested that the granite columns came from this Middle Kingdom temple although he was not sure where the structure was located at that time. As we shall see, the question of the original setting of the columns is still contested. In the Eighteenth Dynasty, perhaps under Tuthmosis III (1540–1504 BCE), the temple was reconstructed on a new plan which included the portico and the reuse of the columns. Then, in the Nineteenth Dynasty, Ramesses II (1279–1212 BCE) added to the temple and raised the columns on granite bases. He also inscribed the columns with his cartouches, as we see today. His son and successor, Merneptah, began to add his own cartouches. Later still, perhaps in the Twenty Third and Thirtieth Dynasties, the temple underwent further restorations. At some time, the columns were raised further by the insertion of white sandstone bases between them and their original granite bases. Having base and column of such differently coloured stone seems rather unconventional. The sandstone bases were inscribed with the name of Ramesses II. If they were not added by him, they must have come from one of his constructions elsewhere.

Petrie was rather unimpressed with some aspects of Naville's work. He was critical of the lack of a plan of the temple and of any diagrams showing the location of finds. He also drew attention to some of the errors made by Naville in recording the site.

The columns had already been removed by Naville; all that remained was one capital, which Petrie said belonged to the column which had been sent to Bolton in England. This made it difficult for Petrie to draw a plan of the locations of the individual columns. Furthermore Petrie found that the few measurements Naville had given were incorrect. However, on the basis of the photos taken by the Rev. W. MacGregor and published in Naville (1894), Petrie believed he had reconstructed, to within a few inches, the positions of the columns (Figure 4).

The columns had been distributed without any measurements being taken. So Petrie asked the curators of the Museums to which the columns had been sent to measure the columns for him. We do not know who measured the Adelaide column for him but Petrie included its measurements and noted that it was in Adelaide (Petrie 1905: 14).

All of this meant he could identify the locations of the columns in the temple and identify each in the photos. On this basis he drew up his reconstruction of the portico (Figure 3).

It can be noted that Petrie's reconstruction features four columns on each side of the entrance for a total of eight. This is despite the fact that only six had been found, and he could not find any remains of the two extra columns or their bases! He argued that without two additional central columns, the architrave, which he reconstructed from the remnants of its inscription, would not have been able to span the distance

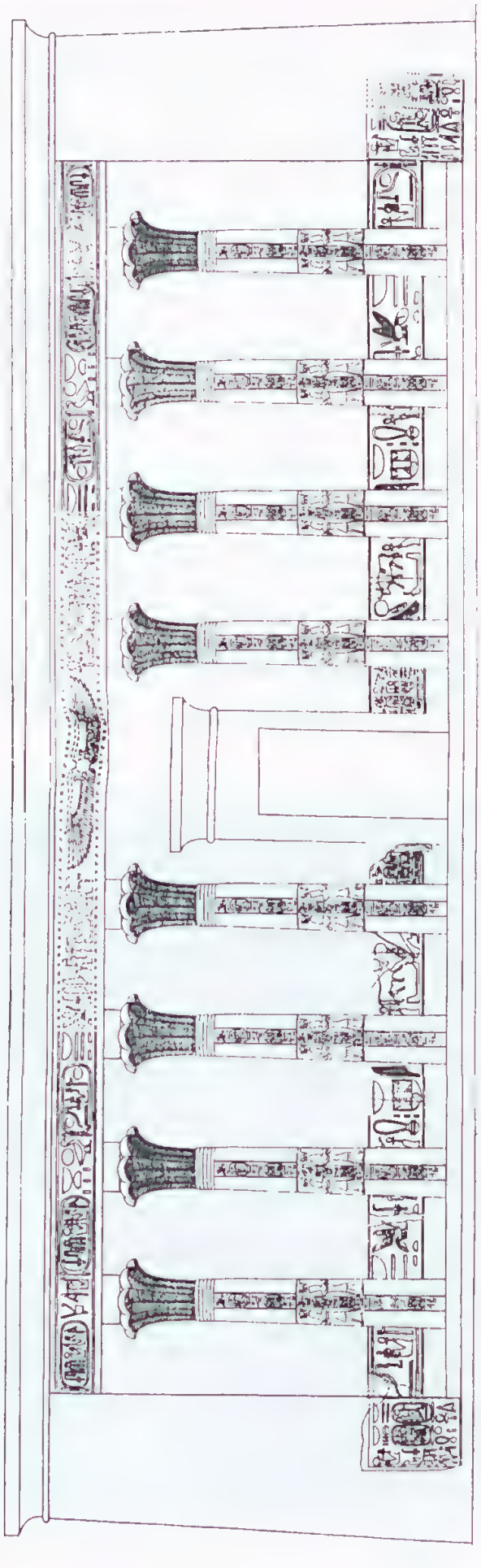


FIGURE 3. Petrie's reconstruction of the temple portico. From Petrie 1905, Plate VIII, top diagram.

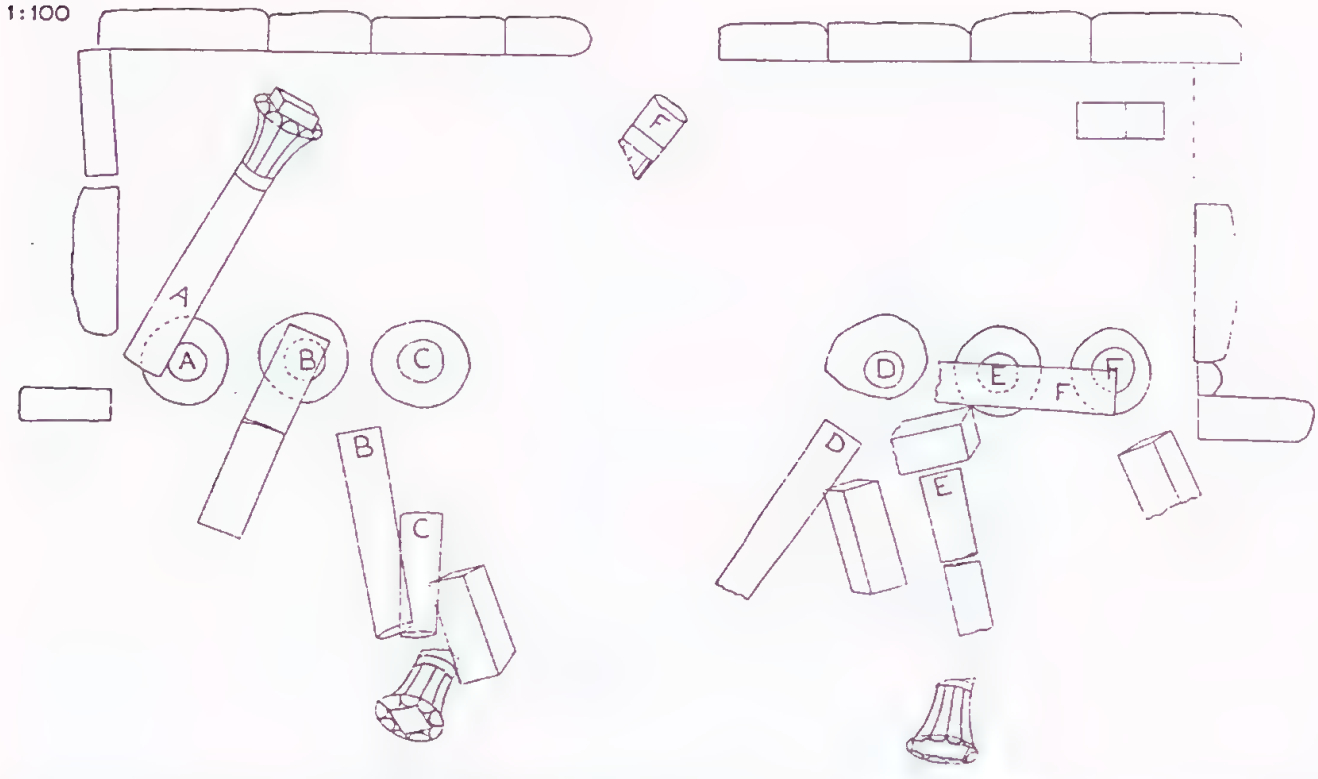


FIGURE 4. Petrie's reconstructed drawing of the temple portico, including the location of the columns, as discovered by Naville. From Petrie 1905, Plate VIII, bottom diagram.

FIGURE 5. General View of the Temple of Heracleopolis Magna. From Naville 1894, Frontispiece.

between the next two columns. If this is accepted it raises the intriguing question as to when and how all traces of the two extra columns were removed. Based on the following reconstruction the Adelaide column is the third from the left (i.e. column C).

Figure 4 is Petrie's reconstruction of the temple portico as discovered by Naville. The line of blocks at the top of the diagram is the lowest course of the inscribed limestone wall of the facade which stood behind the columns and was roofed to form a colonnade. In the centre is the doorway which gave access to the inner courts of the temple. The drawing reconstructs where Petrie concluded the columns and their respective bases were found by Naville. Column A is the complete column in the British Museum, column B is in Boston (the object lying on top of base B is not a column but an inscribed block as can be seen in the photo, Figure 5), C is the top section of the Adelaide column (part of which must have been found outside the area of Petrie's drawing), D is the column in Manchester, E is the column in Bolton and F is the column in Philadelphia.

Petrie based his reconstruction on the following three photos from Naville's report as well as his own excavations of the bases of the columns. It was a clever piece of archaeological detective work, for which Petrie was justly famed.

Figure 5 provides a general view of the portico (compare with Petrie's diagram above). The line of inscribed blocks running across the centre of the photo is the lowest course of the facade of the portico which stood behind the row of columns; on the far left is column A with its capital intact; in the middle foreground lies column B and behind it the top section of column C, the Adelaide column; the top of column F can be seen just in front of the entrance doorway in the facade; to the right, column D lies still half buried in the debris and on the far right midground is column F. Perhaps the section of column which can just be made out in the right hand bottom corner of the photograph is the other section of the Adelaide column. Petrie's drawing does not extend far enough to include this.

In Figure 6, making use of Petrie's diagram, we can identify, in the foreground, column B now in Boston and, nearby, the capital which presumably belongs to it. Immediately behind it is the top section of column C, the Adelaide column. In the

FIGURE 6. Columns and Architraves from the Vestibule of the Temple of Heracleopolis Magna. From Naville 1894, Plate V.

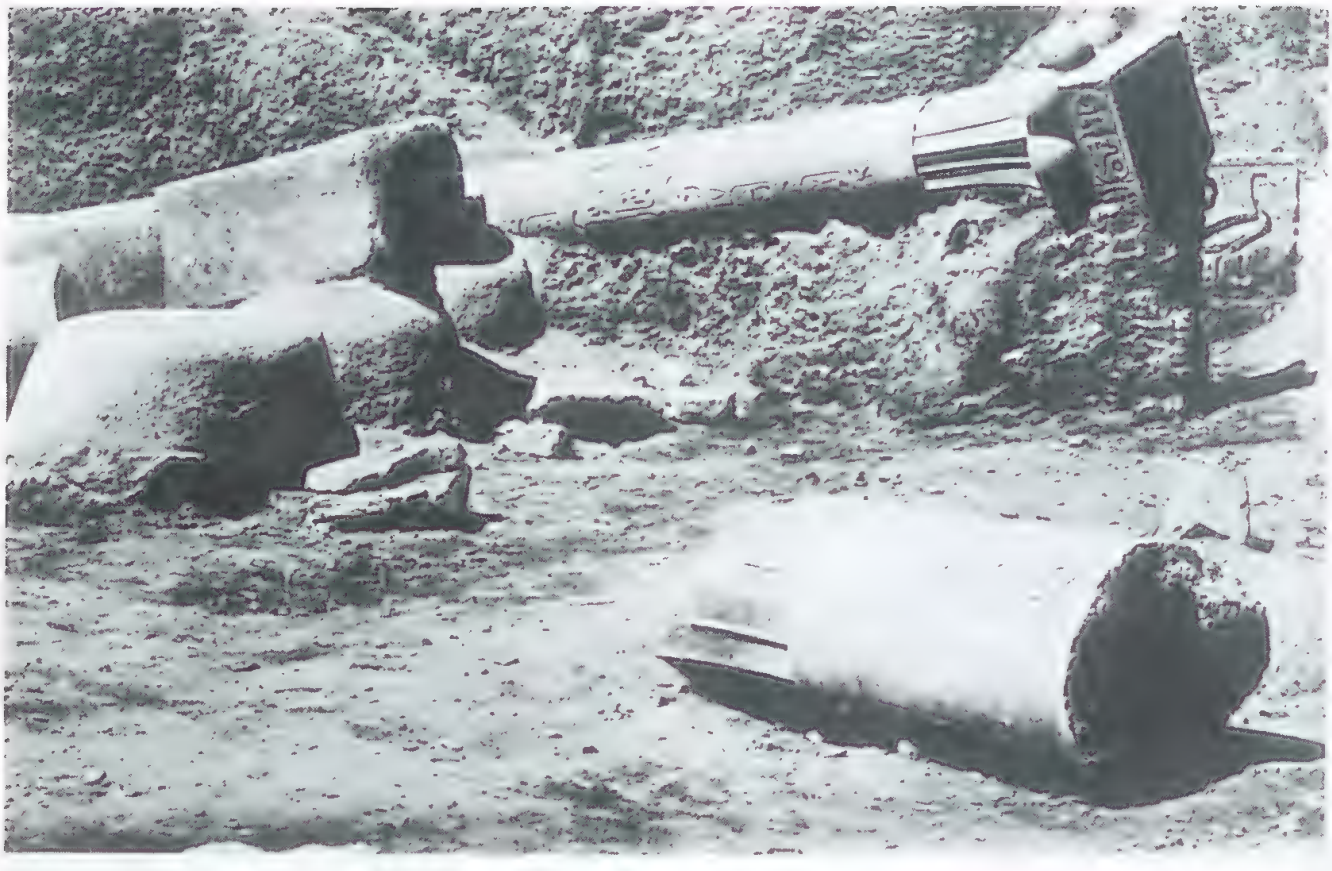


FIGURE 7. Columns and Architraves from the Vestibule of the Temple of Heracleopolis Magna. From Naville 1894, Plate VI.

right midground is column D now in Manchester and, above it, in the top right hand corner, column F now in Philadelphia.

In Figure 7 we can identify, in the right foreground, the top of the shaft of column F which also includes the bottom section of the palm capital. In the background is the complete column A now in the British Museum. On the left, one behind the other, are the granite bases of the three left hand columns.

General Plan Of The Temple

The full extent of the temple at the time of Ramesses II was revealed by Petrie and is shown in Figure 8. The entrance was through a large open courtyard (I) which was flanked by rows of columns fronted by statues. Mokhtar (1983: 81) says these columns were of granite with palm leaf capitals but it is not clear where he obtained this information as the columns were entirely missing. He may be confusing them with the columns of the portico. The columns were more likely of limestone.

At the eastern end of the courtyard was the portico (II) from which the Adelaide column comes. This portico served as the entrance to the inner parts of the temple and consisted of a covered colonnade fronting an inscribed facade, which measured about 18.5 m. by 6.3 m (Petrie 1905: 13). The inscription on the facade consisted of hieroglyphic signs 60 cms high and gave the name and titles of Ramesses II. This was followed by the text 'He erected [it] as a monument for his father Herishef, the King of the Two Lands.' (Mokhtar 1983:83).

The entrance through the portico gave access to the hypostyle hall (III), one of the oldest parts of the temple (Mokhtar 1983: 86). Here Petrie discovered the small (6 cms high), solid gold statue of Herishef dating from about 730 BCE which has been called 'one of the largest and finest gold figures known to be excavated in Egypt' (Mokhtar 1983: 86–87). The statue weighs 35 grams and is now in the Museum of Fine Arts, Boston.

Next was the small hall (IV) which originally had four columns and later eight. Only the bases remain.

Finally there was the sanctuary area (V) of which little remained. Petrie suggested it consisted of a central sanctuary and two side

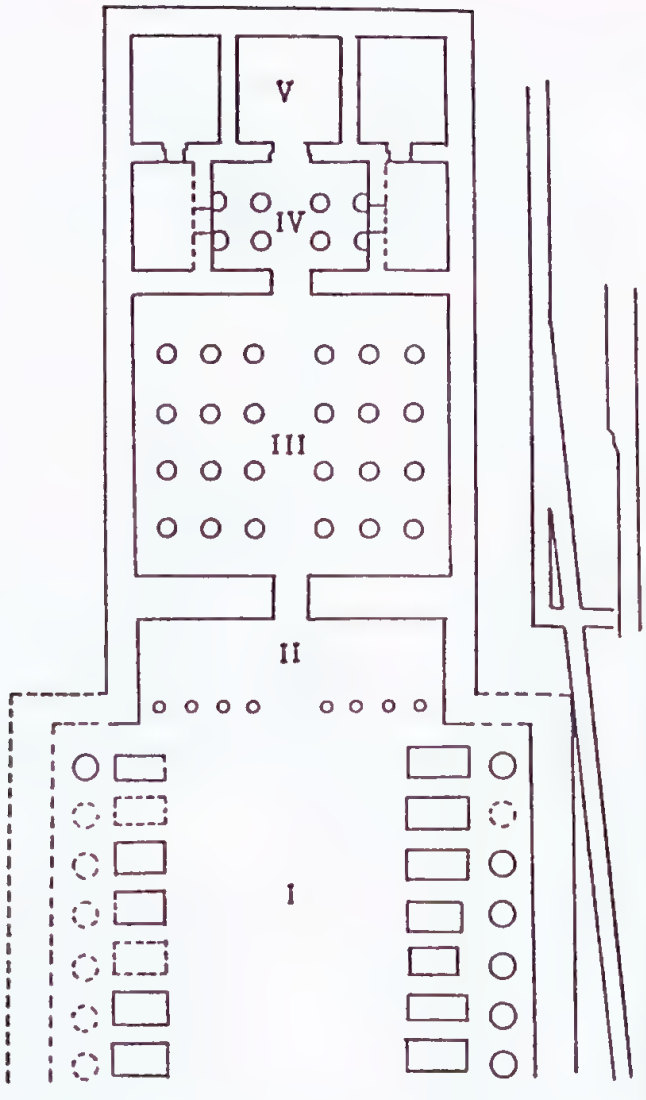


FIGURE 8. General Plan of the Temple of Heracleopolis Magna. From Mokhtar 1983:88, Figure 18.

rooms. The layout of the temple reflected the canon of the Egyptian cultic temple of the New Kingdom. This included a series of halls leading eventually to the sanctuary where the statue of the god resided in its shrine as the focus of the daily temple ritual.

Petrie found no evidence of a temple on the site prior to the Middle Kingdom, discovering only a few re-used blocks which may be dated to an earlier era. However, Mokhtar (1983: 77) argues that a temple existed on the site from the First Dynasty. He notes that a temple of Herishef is mentioned on the Palermo Stone. Furthermore the prominence of the city in the later lists of cities of Egypt and its significance in mythology, suggest it must have had a significant temple at an early date. Mokhtar believes the archaeological evidence for a temple may have been destroyed when the city was conquered by the Theban rulers of the 11th and 12th Dynasties. It is also possible that the earlier temple was in another part of the largely unexcavated site.

The Origin Of The Columns

As Petrie remarked (1905: 7), 'The granite palm columns of the portico have been recognised as probably of the XIIth Dynasty since they were found . . .' He suggested that their position in the portico may have been established during the 18th Dynasty rebuilding, and inscriptions were added

FIGURE 9. Palm column in the mortuary temple of the Pyramid of Sahure at Abusir. Author's photograph.

to the columns by the 19th Dynasty pharaoh Ramesses II and his son Merneptah. If they were from a Middle Kingdom structure, their original location remains unknown.

Rita Freed of the Boston Museum has suggested an earlier origin for the columns (personal communication, 16 August 1994). She has traced their origin based on the style of the palm capitals. She argues that they are typical of palm capitals of the Old Kingdom belonging to the pyramid temples of Unas and Isesi at Saqqara, and of Sahure at Abusir. In this case the closest similarities are with the columns of Isesi (5th Dynasty, c.2414–2375 BCE). This suggests that the columns could have been taken from the mortuary temple of this king (cf. Figure 9). As William Stevenson Smith has commented, referring to the column in the Boston Museum,

> There is little either in the proportions or the treatment of details to distinguish this column from the Old Kingdom form as it is found in the temples of Sahura and Unas (Smith 1960: 79).

There is no evidence to determine whether the columns were removed from Saqqara to Herakleopolis sometime after the Old Kingdom or whether they belonged to an Old Kingdom structure at Herakleopolis. However, there is no doubt about their reuse in the reconstructed 18th Dynasty temple or their later inscription by Ramesses II.

The God Herishef

The temple was dedicated to the god Herishef, who is depicted on the Adelaide column receiving offerings from Ramesses II. The other columns feature other gods in the same position. Herishef is depicted as a man with a ram's head. There were many ram gods in Egypt, among the most important being Amun of Thebes and Khnum of Elephantine. The ram seems to have been chosen to represent divinity because it was linked with fertility and sexual power. Amun was represented by a species with curled horns which came to Egypt from the Middle East during the Middle Kingdom. The ram representing Herishef was of a different species with more ancient local origins and has horizontal horns which are twisted (Altenmüller 1977: 1015). He usually held the *was* (*w3s*) sceptre and wore the Atef crown which was worn by kings and gods. This crown included the tall white conical crown of upper Egypt surmounted by the sun disk, and with feathers on each side. At the base of the crown were the two horizontal ram's horns.

FIGURE 10. The God Herishef. From Mokhtar 1983:157, Figure 26.

The god's name, Herishef (*Ḥry-š.f*) means 'He who is upon his lake.' Some think this lake refers to Lake Moeris, the large lake in the Faiyum because Ihnasya is so close to this area (Mokhtar

1983: 147). On the other hand it may refer to a more local body of water which is no longer identifiable, perhaps even the sacred lake customarily attached to each temple. The Greeks transcribed the god's name in such a way that it was read as Harsaphes (or Arsaphes) by scholars. Hence the variations in the writing of the name found in different texts.

The Column Comes To Adelaide

In November 1891, Amelia B. Edwards, the famous Honorary Secretary of the Egypt Exploration Fund, wrote to the 'National Museum of South Australia' [sic] offering to donate to the Museum two fragments of a column of Ramesses II (Letter, State Records of South Australia GRG 19, Series 58). This offer may have been an outcome of the earlier visit to London by Rev. William Roby Fletcher who was gathering Egyptian antiquities for the Museum (*The South Australian Register*, 8 July 1899). Roby Fletcher was in London in mid-1890 and in his report he mentions that he approached the Egyptian Exploration Fund and was told that only subscribers to its work could receive objects from its excavations (Fletcher 1891: np). C. E. Owen Smyth stated in his reminiscences that the pieces of the column had been presented to Roby Fletcher while he was in England (*The Register*, 25 October 1923).[2] However, neither Roby Fletcher nor Amelia Edwards' letter mention such a presentation and it may simply have been that the Fund knew of the interest of the South Australian Museum because of Roby Fletcher's visit and so wrote with the offer.

In a letter dated January 6 1892, the general director and secretary of the Museum committee, Rob Kay, replied to Amelia Edwards that the members of the committee 'accept this donation with much pleasure' (State Records GRG 19/14 Vol. 13 Folio 97 and 98 Letter Book; see also Folio 96 for letter to SA Agent General in London asking that arrangements be made for transport). He added that the committee 'would be glad to have one of the plaster casts of the capital of the column referred to in your letter'. He also inquired as to what type of base, if any, the column should have. The column arrived in early 1892 and, when accession numbers were assigned many years later, it was given the number A40015. It was to remain in its boxes (the two pieces were packed in separate boxes) for the next eight years.

There are slightly different accounts of the decision to erect the column. Without noting the year, Hale (1956:72) reports that the Museum committee was concerned because the entrance to the Museum was being interfered with by the local military force which used the square in front of the North wing as its drill-ground. The committee urged the Board of Governors of the Public Library, Museum, and Art Gallery to grass the area and erect the column to keep the military away! Since the first dedicated Museum building, the North Wing, was constructed in 1893 and formally opened on 12 January 1895, this urging must have been about this time.

The Superintendent of Public Building of the time, Mr. Charles Edward Owen Smyth, has a different story. In his reminiscences he notes that when he was landscaping the area in front of the North wing of the Museum he asked for the column to form a centre piece. Although it is not entirely clear, he seems to suggest that the new Parade Ground behind Government House was already in use from 1892 and mentions that the drill shed was moved to the new Parade Ground without providing a date. Since the column pieces were stored and the capital carved in the drill shed, it must have been removed as part of the landscaping associated with the erection of the column (Owen Smyth 1923 op. cit.). In the speeches at the unveiling of the column in 1899, reference was made to a 'hideous drill shed which prevents us from appreciating the full beauty of this enclosure' (*The Advertiser*, 8 July 1899, p.8), so the drill-shed was not removed until after the erection of the column.

Owen Smyth, who was known as a person of forceful character, approached Mr (later Sir) George Brookman to assist in the erection of the column (*The South Australian Register*, 8 July 1899). A donation of £200 (Hale 1956: 72) was forthcoming. This enabled a capital to be carved

[2] Owen Smyth's reminiscences came thirty years after the fact and despite his intimate involvement in the events, in several respects seem to be incorrect. For example he mentions the column being in three pieces and that a cast of the base was supplied as well as of the capital, neither of which are supported by the contemporary letters. A scrap book of cuttings from the Register of all of Owen Smyth's reminiscences may be found in the Mortlock Library of South Australiana (V1011 – see References).

from granite which was mined at Lane and Opie's quarry at Swanport on the Murray. Today, when travelling from Adelaide towards the Swanport bridge over the Murray River, a large granite outcrop can be seen to the left of the highway which is known as Haystack Rock. This was the area of the Swanport granite quarry and may have been the actual site of the mining of the granite (personal communication, 7 December 1996 from Ken Wells, President, Murray Bridge Historical Society). Owen Smyth in his reminiscences tells how he and Sir Robert Thomas of *The Register* journeyed to Murray Bridge and 'saw some suitable red granite in a swamp some few miles down the river' (Owen Smyth 1923). This description would fit the area described above. Owen Smyth had the granite transported to Adelaide and stored in the old drill shed which still stood on the eastern side of the old Parade Ground in front of the museum building. Here the capital was cut as an exact replica of that on the complete column at the British Museum, a plaster cast of which had been provided at the time the column had been donated. The unveiling and positioning of the capital upon the shaft was carried out on the afternoon of Friday, 7 July 1899. Mr. George Brookman performed the ceremony. The speeches given on the occasion, in the presence of many of the dignitaries of the colony, were reported at length in the newspapers of the next day (*The Advertiser* and *The South Australian Register*, see References). Owen Smyth had planted some palm trees in the area a few years earlier as part of his landscaping of the northern side of North Terrace.[3] He now completed his vision for the area around the column by adding more palm trees. As he noted in his reminiscences:

> The palms were planted round about to make the old Egyptian ghosts who may haunt the column feel more at home, and incidentally to add to the beauty of the little green spot, so restful to the eyes on a blazing hot Australian summer day (Owen Smyth 1923).

This romantic interpretation should be considered in the light of the fact that he had used palm trees extensively in his landscaping of North Terrace for some years before the column was even donated to South Australia! (Healey 1996; Sumerling 1992).

The Annual Report of the Board of Governors of the Public Library, Museum, and Art Gallery for that year (Report 1899: 5) noted that the column had been erected and that Professor Edward von Blomberg Bensly of the University of Adelaide, who was Honorary Curator of Archaeology from 1897 to 1901 (Hale 1956: 72), had written to the British Museum for a translation of the inscription on the column. The details of the response from E. A. Wallis Budge are given later in this article.

When Alan Rowe was in Adelaide, between about 1915 and 1922, he prepared a catalogue of the Egyptian collection of the Museum (Rowe 1920). Unfortunately it was never published, but a painting by Gustave A. Barnes was prepared as the frontispiece for the intended publication. The painting showed an imaginative reconstruction of the column as it might have appeared in its original location. This painting is still held in the Museum archives (South Australian Museum, Anthropology Archives Acc. No. 126, GP No. 273), has been published in Robert Merrillees (1990: 26) and is reproduced here as Figure 11. It is obvious that Barnes used one of the photos in Naville's publication for the background (cf. Figure 6), adding the erect and complete Adelaide column to the foreground, despite the fact that the Adelaide column is depicted lying behind the erect column!

The Inscription

There have been at least two attempts to translate the inscriptions on the column. Neither, apparently, was published. The first translation was done soon after the column was erected. A letter exists in the files of the South Australian Museum (South Australian State Records GRG 19 Series 58) from E. A. Wallis Budge of the British Museum to Professor Edward von Blomberg Bensly. Wallis Budge had been sent photos of the column with the request to provide a translation. In his letter of the 21 March 1900 (Letter 2 315, State Records of South Australia GRG 19 Series 58) he offered a translation of some of the texts. He also suggested text for the column's identifying label and returned the photos on which he had indicated the sections of his translation. All of these may now be found in the archives.

The second, more comprehensive translation, was by Alan Rowe. Born in 1891 in England,

[3] These may be seen in a photo of the North Wing taken shortly after its construction in 1893 (Hale 1956, facing p.69).

FIGURE 11. Gustave A. Barnes' painting imaginatively reconstructing the Adelaide column among the ruins of the temple of Herishef. Photograph: South Australian Museum Anthropology Archive.

Rowe lived in Adelaide for a number of years and was appointed Honorary Custodian of Archaeology in the Art Museum.

> In 1918 Alan Rowe, then a young man, and later to become a well-known Egyptologist, compiled a catalogue of the archaeological collections and pointed out errors in the translation on the label describing the Ahnas Egyptian Column (Hale 1956: 129).

He produced a detailed transcription, transliteration and translation of the text on the column for his catalogue of the Egyptian Collection which unfortunately was never published. Rowe's translation has only minor differences from the translation which follows. Merrillees (1990: 36) gives an engaging account from Sir Mark Oliphant of his attendance at a lecture by Alan Rowe in about 1918 which began at the column and included a translation of its text before the group moved into the Museum to view the mummy and coffin of Renpit-Nefert.

The inscription on the column occurs in a horizontal cartouche on the top of the restored capital and in three vertical registers, or divisisions, on the shaft of the column. The three registers on the shaft of the column each take approximately one third of its height, so we can refer to upper, middle and lower registers. Interestingly the hieroglyphs on the south and east sides of the column face to the left and hence are read from left to right while those on the north and west sides face to the right and hence are read from right to left. This orientation was determined by the location of the column. We can see from Petrie's reconstruction (Figure 3) that the north side of the column in its current location would have faced the entrance to the temple. This side shows, in the middle register, scenes of Ramesses II facing towards the god Herishef who is depicted as though emerging from his temple. On the rear of the column was the inscription now found on the southern side, with which our translation begins.

The scene of Ramesses II making offerings to the god Herishef is in the middle register on the east and west sides. Ramesses is wearing the blue crown and Herishef is wearing the white conical crown, which bears a feather on each side and the sun on its top. At the bottom of the crown are the ram horns. Herishef holds in his outstretched left hand the *was* (*wȝs*) sceptre of power and by his side the right hand holds the symbol of life, the *ankh* (*ʿnḫ*). He also wears a lappet wig and straight kilt. Ramesses offers to Herishef, in his right hand, a cup bearing burning incense (the flame is indicated rising from the container). Ramesses wears a pointed kilt with carved details. He also wears a collar, as well as arm and wrist bands.

Each figure has his name inscribed above and in front of his crown. Ramesses' name is inscribed inside two cartouches (the name rings which enclose the Pharaoh's name) while Herishef's is simply made up of the signs for his name plus his divine determinative (the seated figure of the ram-headed god).

The column was broken when discovered and was shipped to Adelaide in two pieces. The join can still be seen across the centre of the middle register. The break did some minor damage to some of the inscriptions and figures.

In four panels on the lowest register there are traces, between the vertical inscriptions of Ramesses II, of other inscriptions which were apparently not cut so deeply or were never finished (inscription lines 6, 7, 22 and 23). As a result they can only be read with great difficulty and in the right light. This is why they are shown with cross hatching in the following transcription. The most legible is that on the south-east side of the column, when the sun or artificial light rakes across the inscription. It consists of the names of Merneptah, the thirteenth son and successor of Ramesses II. Interestingly, the very first hieroglyphic sign of Merneptah's inscription on the south-east side (line 6) which is the basket sign (*nb*) has been properly cut. It is the only sign of Merneptah's titulary which was finished. Does this mark the point where the carver was interrupted, never to return? The same inscription of Merneptah's name can be read with a good deal more ease on the column in the British Museum and it leaves one wondering if the exposure of the South Australian column to the elements has led to the fading of the carving.

The inscriptions on the column are repetitive, featuring time and again the throne name and personal name of Ramesses II in cartouches. The throne name was the name given to the king when he was crowned and is the name which often occurs in inscriptions. In Ramesses' case his throne name was something like User-Maat-Re-setep-en-Re, which if translated could mean 'Strong is the Truth of Re, chosen of Re'. His personal name was Ramesses, which probably meant 'It is Re who created [lit. gave birth to] him'. The enumeration of the Ramesses (e.g. Ramesses II, Ramesses IX) of course was not used by the ancient Egyptians but has been developed in modern times.

In the following, the transcription, transliteration, and translation of the text is given. The transliteration is a system modern scholarship uses to represent the sound of the Egyptian words. Vowels are missing because hieroglyphic writing didn't feature them. The lines are numbered from one to thirty three beginning on the south side of the column. While on the column the inscription is written in vertical columns (or lines), and often faces right to left, the entire inscription is given here reading left to right in horizontal lines so that the translation can be readily linked to the hieroglyphs. Sections which are cross hatched are either damaged or very difficult to read.

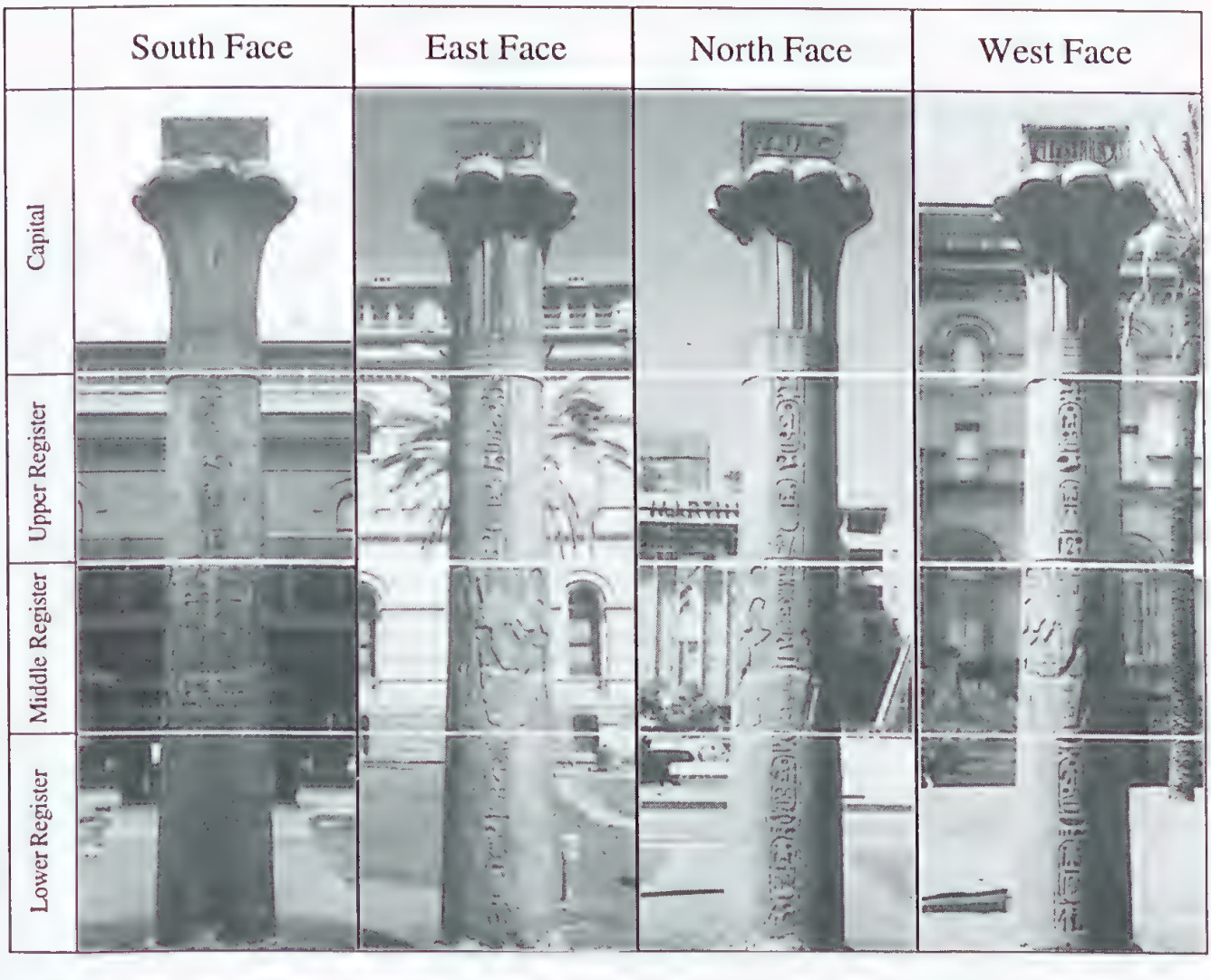


FIGURE 12. The four sides (or faces) of the South Australian Museum's Egyptian column showing the major divisions. Within each division the cartouches may be seen as either horizontal (e.g. on the capital) or vertical (mainly within the registers) lines of hieroglyphs. For easy reference each line has been numbered in the text, beginning on the capital of the South face with line 1 and finishing on the bottom of the West face with line 31. In the text all cartouches are drawn left to right irrespective of their orientation on the column. This allows the translation to be aligned with the relevant hieroglyphs (see below).

On the South side (i.e. the side of the column facing North Terrace), the middle register features two vertical columns with the throne name (line 3) and personal name (line 4) of Ramesses II followed by the epithet, 'beloved of Herishef'. In the lower register to the east of Ramesses II's inscription can be seen the faint outline of Merneptah's inscription (line 6) with the well carved basket (*nb*) at its beginning.

Line 1. Capital – South

Wsr-Mꜣᶜt-Rᶜ-stp-n-Rᶜ mry Ḥry-š.f
User-Maat-Re-setep-en-Re beloved of Herishef

Line 2. Upper register – South

nsw-bity Wsr-Mꜣᶜt-Rᶜ-stp-n-Rᶜ sꜣ Rᶜ Rᶜ-ms-sw mry Ỉmn di ᶜnḫ
King of Upper and Lower Egypt, User-Maat-Re-setep-en-Re, son of Re,
Ramesses, beloved of Amun, given life

Line 3. Middle register – South

nsw-bity nb tꜣwy Wsr-Mꜣᶜt-Rᶜ-stp-n-Rᶜ mry Ḥry-š.f
King of Upper and Lower Egypt, lord of the two lands, User-Maat-Re-setep-en-Re, beloved of Herishef

Line 4. Middle register – South

sꜣ Rᶜ nb ḫᶜw Rᶜ-ms-sw mry Ḥry-š.f
Son of Re, Lord of Appearances, Ramesses, beloved of Herishef

Line 5. Lower register(centre) – South

nb tꜣwy Wsr-Mꜣᶜt-Rᶜ-stp-n-Rᶜ nb ḫᶜw Rᶜ-ms-sw mry Ỉmn mry Ḥry-š.f
Lord of the Two Lands, User-Maat-Re-setep-en-Re, Lord of Appearances,
Ramesses, beloved of Amun, beloved of Herishef

Line 6. Lower register(to right of line 5) – South

nb tꜣwy Bꜣ-n-Rᶜ mry nṯrw nb ḫᶜw Mr-n-Ptḥ ḥtp ḥr Mꜣᶜt mry Ḥry-š.f
Lord of the Two Lands, Ba-en-Ra, beloved of the gods, Mer-en-Ptah,
pleasing before Maat, beloved of Heryshef

Line 7. Lower register (to left of line 5) – South
Very difficult to read but similar inscription to line 6.

On the East side of the column, the middle register shows the scene of Ramesses II offering to Herishef. Their names are given just above and in front of their crowns (lines 10, 12 and 13). In front of the body and legs of each figure are inscriptions (lines 14 and 11) indicating that Ramesses II offers Herishef incense while the god offers the king, in return, stability, life, and power. Note that the hieroglyphs in these lines face toward the figure being spoken to, as though addressed to him and that, on this side, the hieroglyphs face from right to left (except for the inscription on the capital and those in front of Herishef) as described above.

Line 8. Capital – East

Rᶜ-ms-sw mr Ỉmn
Ramesses beloved of Amun

Line 9. Upper register – East

nsw-bity Wsr-Mɜᶜt-Rᶜ-stp-n-Rᶜ sɜ Rᶜ Rᶜ-ms-sw mry Ỉmn mi Rᶜ
King of Upper and Lower Egypt, User-Maat-Re-setep-en-Re, son of Re, Ramesses, beloved of Amun, like Re

Line 10. Middle register (above crown of god) – East

Ḥry-šꜣ.f
Herishef

Line 11. Middle register (in front of figure of god) – East

dỉ.n n.k ḏd ᶜnḫ wɜs nb
I have given to you all stability, life and power

Lines 12 and 13. Middle register (in front of crown of Ramesses) – East

nb tɜwy Wsr-Mɜᶜt-Rᶜ-stp-n-Rᶜ

Lord of the two lands, User-Maat-Re-setep-en-Re

nb ḫᶜw Rᶜ-ms-sw mry Ỉmn
Lord of appearances, Ramesses, beloved of Amun

Line 14. Middle register (in front of Ramesses) – East

irt snṯr n it.f
Giving incense to his father

Line 15. Lower register – East

nb tȝwy Wsr-Mȝᶜt-Rᶜ-stp-n-Rᶜ nb ḫᶜw Rᶜ-ms-sw mry Ỉmn mry Ḥry-šf
Lord of the Two Lands, User-Maat-Re-setep-en-Re, Lord of Appearances, Ramesses, beloved of Amun, beloved of Herishef

On the North side of the column, there are three vertical lines of inscriptions—lines 17 (upper register), 18 (middle register), and 21 (lower register)—as well as the horizontal inscription on the capital, line 16. On the lower register, faint traces of Merneptah's vertical inscription can be seen either side of line 16 (lines 22 and 23). In the middle register the beginning of the offering scenes of the east and west sides involving Ramesses II can be seen in lines 20 and 19.

Line 16. Capital – North

Wsr-Mȝᶜt-Rᶜ-stp-n-Rᶜ
User-Maat-Re-setep-en-Re

Line 17. Upper register – North

nsw-bity Wsr-Mȝᶜt-Rᶜ-stp-n-Rᶜ sȝ Rᶜ Rᶜ-ms-sw mry Ỉmn di ᶜnḫ
King of Upper and Lower Egypt, User-Maat-Re-setep-en-Re, Son of Re, Ramesses beloved of Amun, given life

Line 18. Middle register (centre) – North

nsw-bity nb tȝwy Wsr-Mȝᶜt-Rᶜ-stp-n-Rᶜ sȝ Rᶜ nb ḫᶜw Rᶜ-ms-sw mry Ỉmn di ᶜnḫ
King of Upper and Lower Egypt, User-Maat-Re-setep-en-Re, son of Re, Ramesses, beloved of Amun, given life

Lines 19 and 20. Middle register – North

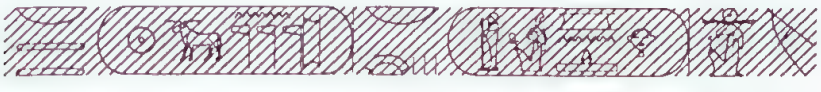
Above the head of Ramesses in both instances is a sun disk with two cobras (the cobra-goddess Wadjet, protector of the pharaoh) emerging from it. Each serpent carries the *ankh* symbol. Under this symbol is the title Behdet[y], meaning 'he who comes from the town of Behdet (Edfu)', a city sacred to the falcon-god, Horus who was identified with the pharaoh.

Bḥdt(y)
The one from Behdet

Line 21. Lower register (centre) – North

nb tȝwy Wsr-Mȝᶜt-Rᶜ-stp-n-Rᶜ nb ḫᶜw Rᶜ-ms-sw mry Ỉmn mry Ḥry-šf
Lord of the Two Lands, User-Maat-Re-setep-en-Re, Lord of Appearances, Ramesses, beloved of Amun, beloved of Herishef

Line 22. Lower register (right) – North



nb tȝwy Bȝ-n-Rᶜ mry nṯrw nb ḫᶜw Mr-n-Ptḥ ḥtp ḥr Mȝᶜt mry Ḥry-šf
Lord of the Two Lands, Ba-en-Ra beloved of the gods. Lord of Appearances. Mer-en-Ptah, pleasing before Maat, beloved of Heryshef

Line 23. Lower register (left) – North

Similar inscription to line 22, very difficult to make out.

On the West side of the column, the middle register shows the scene of Ramesses II offering to Herishef. Their names are given just above and in front of their crowns (lines 27 and 29). In front of the body and legs of each figure are inscriptions (lines 28 and 30) indicating that Ramesses II offers Herishef incense, while in return the god offers the king life and many festival celebrations.

Line 24. Capital – West

Rᶜ-ms-sw mr Ỉmn
Ramesses beloved of Amun

Line 25. Upper register – West

nsw-bity Wsr-Mȝᶜt-Rᶜ-stp-n-Rᶜ sȝ Rᶜ Rᶜ-ms-sw mry Ỉmn mi Rᶜ
King of Upper and Lower Egypt, User-Maat-Re-setep-en-Re, son of Re, Ramesses, beloved of Amun, like Re

Lines 26 and 27. Middle Register (above crown of Ramesses) – West

nb tȝwy Wsr-Mȝʿt-Rʿ-stp-n-Rʿ

Lord of the two lands, User-Maat-Re-setep-en-Re

nb ḫʿw Rʿ-ms-sw mry Ỉmn
Lord of appearances, Ramesses, beloved of Amun

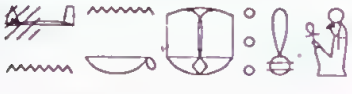
Line 28. Middle register (in front of figure of Ramesses) – West

irt snṯr n it(.f) ir.f di ʿnḫ
Giving incense to his father, who gives the gift of life

Line 29. Middle register (above crown of god) – West

Ḥry-š.f
Herishef

Line 30. Middle register (in front of figure of god) – West



di n n.k ḫbw mi Rʿ
I have given to you festivals like Re

Line 31. Lower register – West

nb tȝwy Wsr-Mȝʿt-Rʿ-stp-n-Rʿ nb ḫʿw Rʿ-ms-sw mry Ỉmn mry Ḥry-š.f
Lord of the Two Lands, User-Maat-Re-setep-en-Re, Lord of Appearances, Ramesses, beloved of Amun, beloved of Herishef

Conclusion

From the time of its origins in the granite quarries of Aswan the Egyptian column has attracted to itself layer after layer of meaning. It began as a plain palm column in a temple of the Middle Kingdom, or perhaps even before that in a mortuary temple of the Old Kingdom. It was reused during the New Kingdom and inscribed by Ramesses II in devotion to the god Herishef. His son Merneptah added his layer by inscribing his own name. The column was discovered by Naville and donated to the South Australian Museum by the Egypt Exploration Fund in the heyday of European excavation in Egypt. In Adelaide its erection became a symbol of colonial pride and it stands today as a symbol of the South Australian Museum's commitment to the preservation of the Footprints of the human story. It would be fitting to celebrate this story and these meanings on the centenary of the erection of the column in its present position on 7 July 1999.

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References

ALTENMÜLLER, B. 1977. Harsaphes. *Lexikon der Ägyptologie* Band II edited by Wolfgang Helk and Eberhard Otto. Harrassowitz, Wiesbaden.

FLETCHER, REV. WILLIAM ROBY 1892 'Egyptian Sketches' Petherick: Adelaide.

GOMAÁ, F. 1977 Herakleopolis magna. *Lexikon der Ägyptologie*. Band II. edited by Wolfgang Helk and Eberhard Otto, pp.1124–1127. Harrassowitz: Wiesbaden.

HALE, H. M. 1956. 'The First Hundred Years of the South Australian Museum 1856 – 1956'. *Records of the South Australian Museum* **XII**, Museum Board: Adelaide.

HEALEY, J. 1996. Some prominent dates in South Australia's History *Friends of the South Australian Museum Newsletter*, **26**(1, 2):8–10.

JAMES, T. G. H. 1988 'Ancient Egypt: the land and its legacy'. British Museum Press: London.

LOPEZ, T. 1974. Rapport Préliminaire sur les Fouilles D'Hérakléopolis (1966) *Oriens antiquus* **13**:299–316.

LOPEZ, T. 1975. Rapport Préliminaire sur les Fouilles D'Hérakléopolis (1968) *Oriens antiquus* **14**:57–78.

MERRILLEES, R. S. 1990. 'Living with Egypt's Past in Australia'. Museum of Victoria: Melbourne.

MOKHTAR, M. G. 1983. 'Ihnasya el Medina (Herakleopolis Magna) its importance and its role in Pharaonic history'. Series Bibliothèque d'étude Institut français d'archéologie orientale du Caire 40: Le Caire.

NAVILLE, E. 1894. 'Ahnas el Medineh (Heracleopolis Magna)'. XIth Memoir. Egypt Exploration Fund: London.

PETRIE, W.M. FLINDERS. 1905. 'Ehnasya: 1904'. XXVIth Memoir. Egypt Exploration Fund: London.

PORTER, B. & MOSS, R. L. B. 1934. 'Topographical Bibliography of Ancient Egyptian Hieroglyphic Texts, Reliefs, and Paintings' Vol. IV Lower and Middle Egypt. Oxford: Clarendon Press.

REPORT. 1899. Annual Report of the Board of Governors of the Public Library, Museum, and Art Gallery of South Australia for 1898–9. C.E. Bristow, Government Printer: Adelaide.

SMITH, W. S. 1960. 'Ancient Egypt: as represented in the Museum of Fine Arts, Boston'. Museum of Fine Arts: Boston.

SUMERLING, P. 1992. The legacy of Owen Smyth's date palms. *Friends of the South Australian Museum Newsletter*, September pp. 2–3.

Archive Sources

FLETCHER, REV. W.R. 1891. 'Report on Commission concerning Egyptian Antiquities for the South Australian Museum.' 24 April 1891. South Australian Museum, Anthropology Archives Acc. No. 122 GP No. 273 (also to be found as an Appendix in his 'Egyptian Sketches' and as South Australian Parliamentary Paper 1891, vol. 3, Paper no. 38.).

OWEN SMYTH, C. E. 'Newspaper Cuttings from *The Register*, 15 October 1923 to 18 August 1924, relating to South Australia' Mortlock Library of South Australiana, reference V1011.

ROWE, A. 1920. 'A Guide to the Egyptian Antiquities in the South Australian Museum.' (Unpublished manuscript, dated from Rowe's accompanying instructions to the printer, 15 November 1920). South Australian Museum, Anthropology Archives Acc. No. 126 GP No. 273.

State Records of South Australia GRG 19/14 Vol. 13, Folio 97 and 98

State Records of South Australia GRG 19 Series 58.

Newspaper Sources

JENSEN, PROFESSOR ROLF 'A pharaoh cry from North Terrace.' *The Australian*, 9–10 January 1982, Weekend Australian Magazine, p.8.

An Egyptian Column: The unveiling ceremony. *The Advertiser*, 8 July 1899, p.8.

The Old Order and the New. *The Advertiser*, 8 July 1899, p. 6.

A Classic Column: A relic of Ancient Egypt unveiled by Mr. G. Brookman. *The South Australian Register*, 8 July 1899, p.5.

OWEN SMYTH, CHARLES EDWARD 'North Terrace Lands: Chapters from History' *The Register*, Thursday, 25 October 1923, p. 9.

SPIRIT BEINGS AND THE ABORIGINAL LANDSCAPE OF THE LOWER MURRAY, SOUTH AUSTRALIA

PHILIP A. CLARKE

CLARKE, P. A. 1999. Spirit beings and the Aboriginal landscape of the Lower Murray, South Australia. *Records of the South Australian Museum* **31**(2): 149–163.

In the historic and ethnographic record for Aboriginal culture in the Lower Murray, there is a body of mythology, on spirit beings, that does not directly relate to a creation period or as is sometimes referred to, the 'Dreaming'. Although not generally associated with land transforming events in the mythology, these beliefs are nonetheless revealing of Aboriginal perceptions of the Lower Murray landscape. This paper provides an overview of the records concerning spirit beings and adds further Aboriginal ethnographic details from the 1980s. A cultural geographical approach is adopted, which considers the role of spirit beliefs in the Aboriginal perception of *place* in the cultural landscape.

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Introduction

In the anthropological literature of Aboriginal Australia, the study of mythology and its relationship to land is generally limited to the deep religious aspects of the creation period, often termed the 'Dreaming'.[1] For Australian anthropology, one consequence of this is the neglect of mythical beliefs linked to spirit beings that were perceived by Aboriginal people to have an existence separate from the 'Dreaming' ancestors. In mythology, these spirits are not 'creators', although sometimes their contemporaries, but rather co-residents of a landscape shared with Aboriginal people. This paper brings together wide ranging written sources and provides new ethnographic material for southern Australia gathered in the 1980s. A focus of the study is the investigation of how the more recent knowledge of Aboriginal people combines pre-European traditions with those that developed from relationships to a landscape altered by British expansion starting in the 1830s.

Sources And Methodology

The Lower Murray region of South Australia is the most heavily worked ethnographic area in southern Australia (Fig.1). The Aboriginal people here are generally known as the Ngarrindjeri. An outline of this diverse literature is provided in detail elsewhere (Clarke 1994, 1995). Briefly, the authors from the nineteenth century can be divided into early explorers and colonists of the 1840s (R. Penney, G. French Angas, W. A. Cawthorne and W. Wyatt) and missionaries from 1840s to 1870s (H. A. E. Meyer and G. Taplin). In the twentieth century there are anthropologists from 1918 to the present (A. R. Brown, A. Harvey, N. B. Tindale, R. M. and C. H. Berndt, P. A. Clarke), a folklorist in 1930 (W. Ramsay Smith), a sociologist in the 1970s (G. Killington) and local historians from the 1980s (R. Linn and L. Padman). Although all these recorders are influenced towards their individual social and disciplinary backgrounds, together they provide an outline of Aboriginal spirit beliefs in the nineteenth and twentieth century.

This paper provides some data from Aboriginal people interviewed in the 1980s by the author. The major Aboriginal sources were Lola Cameron-Bonney, Ron Bonney, Marj Koolmatrie, Paul Kropinyeri and Lindsay Wilson. Their information has a strong relationship to the pre-European past. Nevertheless, it also reflects the development of contemporary cultural forms through the interaction of an indigenous minority and the hegemonic non-Aboriginal culture. The sites associated with the beliefs are often

[1] See Clarke (1995) for a description of Lower Murray 'Dreamings'.

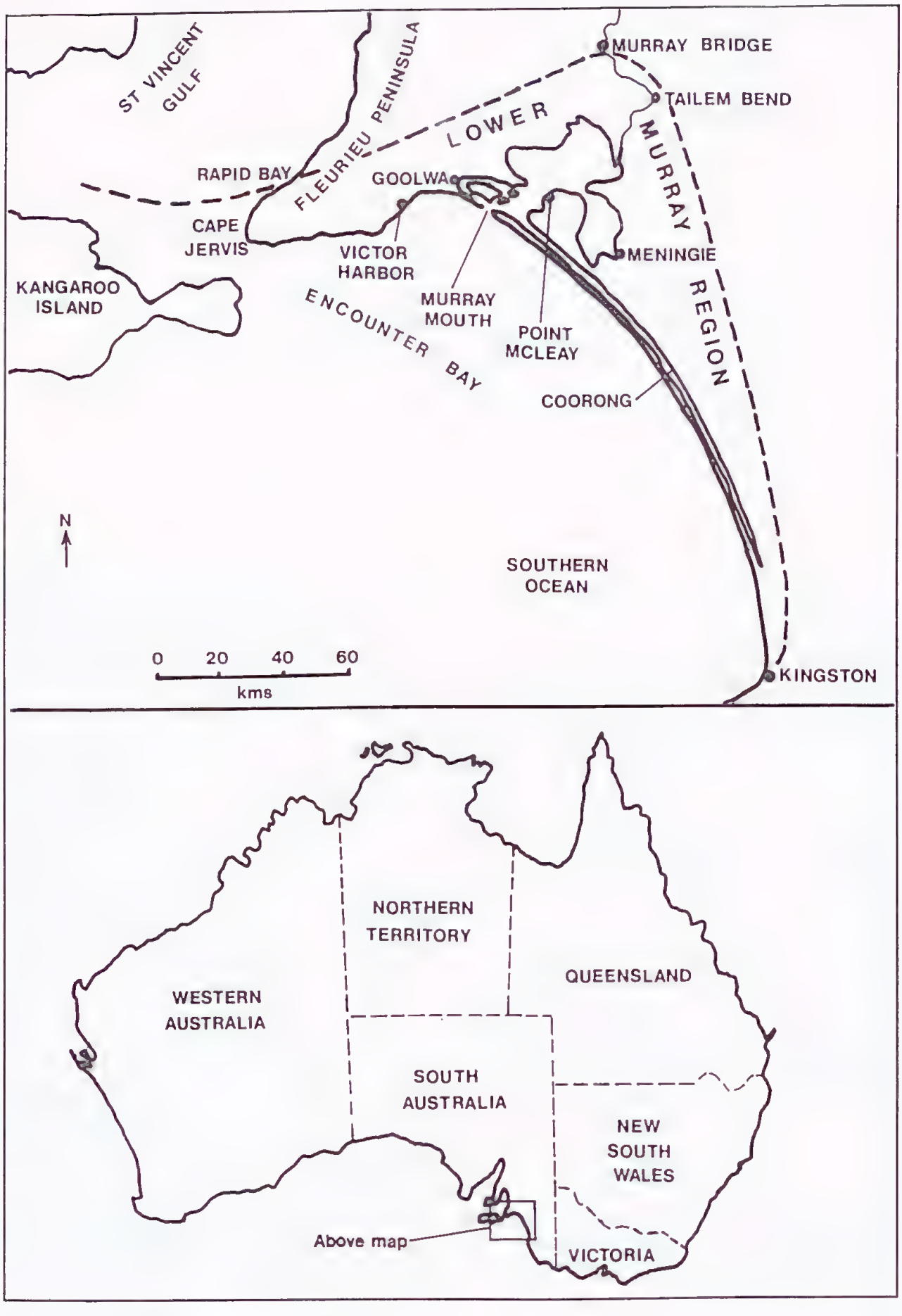

FIGURE 1. The Lower Murray cultural region.

European constructions, such as church graveyards, paths and clumps of trees left in paddocks. During the 1980s in the Aboriginal community of the Lower Murray, knowledge about spirit beings far outweighed that of 'Dreaming' stories. Non-Aboriginal forces have deeply affected the indigenous culture in the Lower Murray region. Thus traditions do change through time.

The study of how space is humanised is a major theme in human geography. How modern landscapes are produced from interaction between human populations and earlier forms of landscape is the concern of the subdiscipline of cultural geography. This paper looks at the linkages between the culture of the Aboriginal inhabitants, their use of the landscape and the perceived territoriality of the spirits. The aims therefore fall within the objectives of cultural geography.

Ethnographic Details

The use of 'spirit being' in this paper covers a wide group of disparate beliefs. Nonetheless, the unifying features are their separateness from both the ancestors involved in the main creative mythological period and the Aboriginal population.[2] Before the arrival of Europeans in Australia, Aboriginal people considered that they were co-residents of the landscape, sharing it with many spirit beings.[3] To Aboriginal people in the Lower Murray, who were probably not unique in this regard, the spirit beings and places associated with them formed distinct parts of the perceived cultural landscape. Unlike the 'Dreaming' ancestors, whose presence is indicated by what they left behind, these spirits existed contemporaneously with people.

In the 1980s most Aboriginal people in southern South Australia no longer possessed detailed information of the body of knowledge the literature has described as the 'Dreaming', but they strongly believed in various spirits.[4] Aboriginal spirit beliefs in the Lower Murray reflect the connection between group identity and *place*. Many of these spirits possessed some human characteristics and, like people, they were dispersed according to attributes of the cultural landscape. Most spirit beings were either greatly feared or at least regarded as a nuisance. Angas says:

> They are in perpetual fear of malignant spirits, or bad men, who, they say, go abroad at night; and they seldom venture from the encampment after dusk, even to fetch water, without carrying a firestick in their hands, which they consider has the property of repelling these evil spirits (Angas 1847: 88).

The term 'mooldtharp' was applied by Angas as a general term for an 'evil spirit' (1847: 96,138). He used it to mean an 'evil' species of flycatcher, an earthquake or a whirlpool. Ramsay Smith said it was 'a spirit which assumes many shapes. It may come as a kangaroo, or a wombat, or a lizard' (1930: 349). The Tangani people of the Coorong believed that the *muldarpi* were decorated and disguised men who came from the west or north to kill them (Tindale 1931–34: 165,229). To the Yaraldi of Lake Alexandrina, a *melapi* or *mulapi* was considered to be a shape changer that killed people (Berndt & Berndt 1993: 205,206). This term, written here as *mu:ldapi*, was used in the 1980s, particularly by Aboriginal people in the Lower Murray, as a term for a generalised 'bad' spirit. The following sections provide detailed information on spirit beings.

Spirit Men

Oral tradition in the local Aboriginal community was rich in stories concerning humanoid creatures that, due to their overall similarity, are described here as spirit men. The

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[2] Lower Murray beliefs concerning *gupas* and *prupi* (ghosts and spirits of local people) will be the subject of a future paper.

[3] Tindale (nd) provides an overview of Aboriginal beliefs concerning spirit beings, which he terms 'little folk' and 'little people', linking them to a 'pygmoid race'. Berndt and Berndt (1989) give ethnographic examples of 'spirit beings' from northern and central Australia. Mountford (1958: 144–159) describes the association between spirit people and land for the Tiwi of Melville and Bathurst Island.

[4] It has been reported by several authors that Aboriginal people in the southern districts of South Australia during the second half of the twentieth century had poor knowledge of their early 'traditional background'. For example, see R. M. Berndt and C. H. Berndt (1951: 197,229–233), Killington (1971: 6), Gale (1972: 13,14), R.M. Berndt (1989: 64), C. H. Berndt (1989: 17), and Berndt and Berndt (1993: 297). Hemming (1988: 192) acknowledged the lack of detailed knowledge concerning the 'Dreaming' in the Lower Murray community during the 1980s, when he claimed that of the people he consulted 'all knew only fragments' of the Ngurunderi mythology.

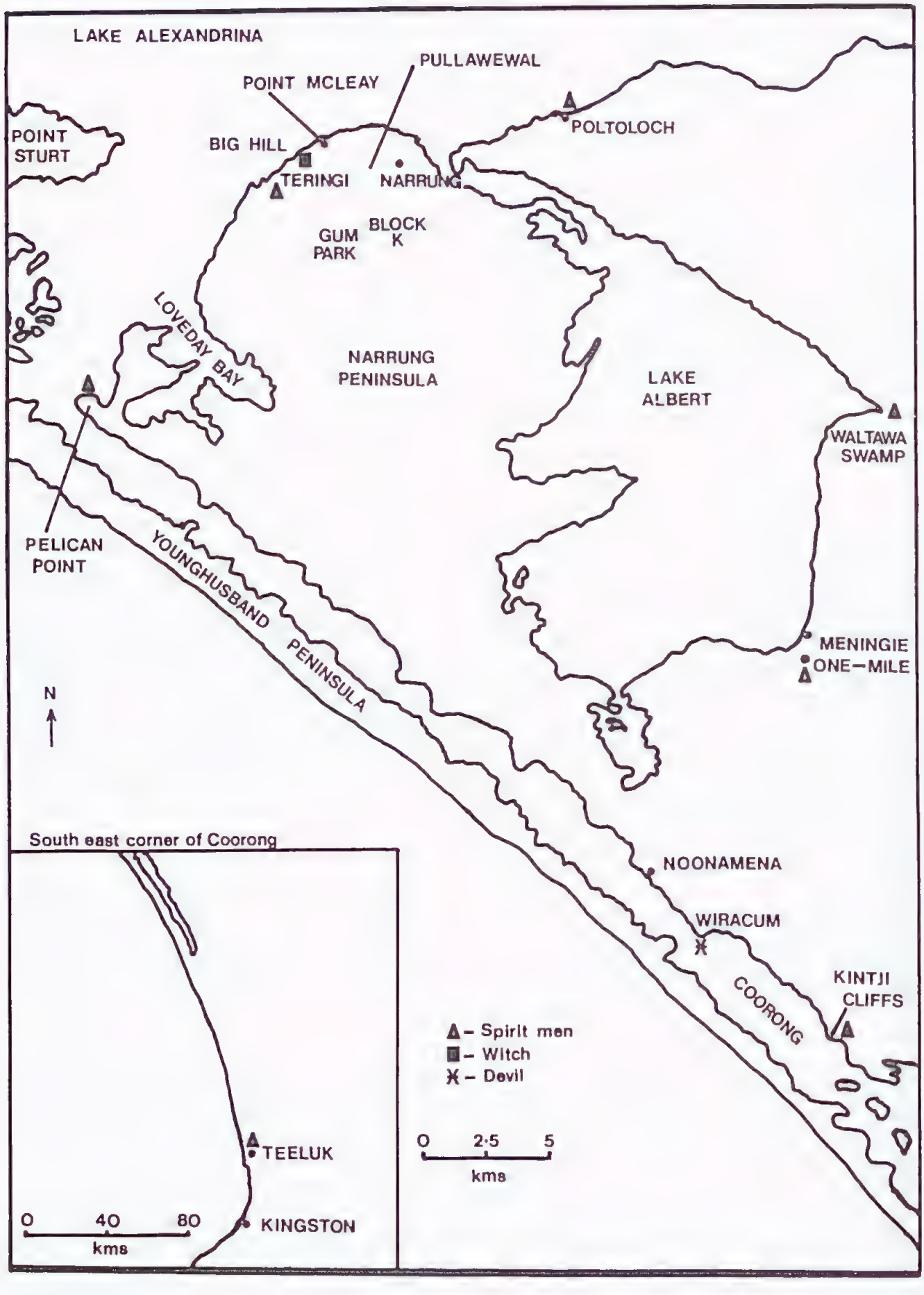

FIGURE 2. Spirit men, witch and devil sites in the Lower Murray.

shared characteristics are that they were generally described as 'coloured' (not black), often little, usually mischievous, and generally associated with a particular type of landscape. The exact relationship of this category of spirits to the pre-European system of beliefs is difficult to determine, as the ethnography has tended to ignore myths that were not concerned with the creative period.[5] In one of the rare written accounts, beings called *raitchari* were described as 'pygmy men who sometimes act as guides to hot men, sometimes lead them astray. They used to live in the scrub' (Harvey 1939). The 'hot men' are presumably people with some form of ceremonial status. It is likely that these spirit men were considered by ethnographers to have more of a fairy-tale quality than deep social or religious significance. Most of the information on these beings discussed here has been gathered from more recent sources. How spirit men were regarded is an important indicator of the degree to which both pre-European and post-European landscapes were humanised.

Although the spirit men were humanoid, Aboriginal people always described them in terms that highlight their distinctiveness from the Aboriginal population. The non-Aboriginality of spirit men was confirmed by their strange colouring and generally small size. They were often reported as being red all over, but there are many other accounts of beings in different colours. For instance, one Aboriginal person interviewed in the 1980s claimed to have seen 'little yellow men' amongst the reeds growing along the mainland side of the Coorong. Another said that 'green men' lived at Poltaloch on the southern shore of Lake Alexandrina. Another variation is 'little white men' with spiky ears, reportedly existing somewhere in the Meningie area. Adults to frighten children into obedience often used the existence of such beings.

The 'little red men' were said to have been seen at Pelican Point, Teringie and Poltaloch (Fig.2). Some people call these particular beings '*kintji* men' or '*kindi* men'. In the ethnographic record they are sometimes described as 'imps' or 'dwarf beings'.[6] A small point on the mainland side of the Coorong just south of Noonamena, known by local Aboriginal people as the Kintji Cliffs, was regarded as the home of *kintji* spirits. Another site, Kindjunga Hill near the Coorong south east of Pelican Point, was recorded as the home of *kindja* spirits who lived in its caves and amongst its rocky outcrops (Berndt & Berndt 1993: 208). These particular spirits were associated with the territory of the Talkundjeri descent group. Other places related to the *kintji* were Kentjingatung and Kintjanga, which are low sandy rises on southern Campbell Park Station near Lake Albert.[7] A sighting of a 'little red man' was reported in the 1950s alongside a swamp near the One Mile Camp situated on the outskirts of Meningie. The spirit surprised an Aboriginal man and his young son walking along a path. The man was paralysed but the boy escaped to raise the alarm. Several men from the camp came to the aid of the father who was still on his back. As with the other spirit men of the Lower Murray, the little red men were often seen in proximity to water, but believed to dwell in higher places.

Aboriginal people disagreed on the colour of the *kintji*. A Lower Murray man stated they were small white men with dark beards. Interestingly, this person knew a story that linked these spirits with the southern Eyre Peninsula landscape. He said that once the *kintji* men told an Aboriginal man at Port Lincoln that they were intending to leave the area on the first calm day. When such a day came along, they all walked in single file into a cloud of mist. It is possible that the name of the *kintji* men, if not the belief itself, originated from outside of the Lower Murray region. The term *kintji* is possibly related to *kinchirra* from the 'Nimbalda' people of the Mount Freeling area of the Flinders Ranges. The term *kinchirra* was reported by Smith (in Taplin 1879: 88) as meaning 'spirit who fetches spirits of the recent dead to the land of the west'. Similarly, *kindara*, was said to mean the 'place where spirits go' in Adnyamathanha language of the Flinders Ranges (McEntee & McKenzie 1992: 34), and *kintjura*, was the 'spirit world' in the Ngadjuri language of

[5] Tindale (1936: 60,61) provides one of the few records of spirit people of the type described here. He mentioned 'little people' who were said, by his informants, to have lived near Marion Bay on Yorke Peninsula. Cameron-Bonney (1990: 19) provides another record from Victoria.

[6] Tindale 'Milerum' manuscript, Stage A #9, Anthropology Archives, South Australian Museum. Tindale considered that fairy penguins may have been the source of this belief.

[7] Tindale 'Milerum' manuscript, Stage A #9, Anthropology Archives, South Australian Museum.

the mid north of South Australia (Berndt & Vogelsang 1941: 9). Similar spirit beings, the *taikuni*, were said by Aboriginal people in the 1940s to have lived in little knobbed hills around the Lower Lakes, Adelaide Hills and north as far as Gawler (Berndt & Berndt 1993: 207,208).

Sightings of these spirits continued during the 1980s. For instance, a Lower Murray man claimed to have sighted two *kintji* men whilst 'swan egging' (swan egg collecting) at Waltawa Swamp, about nine kilometres north of Meningie. The spirits were apparently seen standing amongst reeds. They were described as small, light grey all over, with shoulder length hair and a long neck. Of the face, only the features of the two eyes were noticed. These were shiny black and just under five centimetres in diameter. The spirits reportedly disappeared when the person's gaze shifted for an instant. Another Aboriginal man later told him that he was lucky: it was said that when the eyes of the *kintji* are red, not black as the case in the above beings, they intend to do mischief.

There is some similarity between the 'red men' and the 'natja men' from the Tatiara district of the south east of South Australia. The *natja* men were described in the 1980s as 'red hairy men', also said to look 'like monkeys or orang-utans'. Ramsay Smith records an unlocalised story about a 'queer little red man', called 'Yara-ma-yha-who', that was reportedly told to children as a threat against misbehaving (1930: 342–345). In the 1980s another individual claimed that many years ago 'silver men' were seen on a hill near Teeluk, north of Kingston. These spirits were described as having an 'arrow-like covering' and were blamed for upsetting local cattle. The silver men eluded attempts by an Aboriginal man to capture them.

A common element to many of the accounts of spirit men is that only one or two of them were seen together, usually in swamps and lagoons where Aboriginal duck hunting and 'swan egging' activities occurred. A Lower Murray man reported 'red men' at Pelican Point earlier this century: an Aboriginal duck hunter who had disregarded warnings about these spirit men being there, shot some ducks and started to search for them in the spot where they had fallen. He then noticed a 'red man' was picking up the ducks. The Aboriginal man grabbed his gun and fled. Another story involved a Kingston man, Alf Watson, who was apparently duck hunting with his rifle when he saw a *kintji* man among the *winggi* (sagent sedge).[8] This spirit caused him to freeze and he fell on his back. The *kintji* man came up to Alf and sat on him, feeling his face with interest. This was because this type of spirit man was bearded, whereas Alf Watson was clean-shaven. Alf claimed afterwards that he could feel the *kintji* man's cold bottom on his chest through his flannel shirt. According to several Aboriginal sources, Lower Murray people who hunted in areas that were recognised as being inhabited by 'red men' used to leave one or two ducks behind for them.

Healers, Sorcerers And Wild People

Knowledgeable people, who possessed skills in both healing and sorcery, had an important role in Aboriginal society of pre-European Australia.[9] From the ethnographic accounts, it appears that a powerful person was often both a healer and a sorcerer, depending on context. It is likely that as people grew older, their perceived skills in healing and sorcery balanced the decline in their physical powers. The possession of this knowledge attracted fear and respect from other members of the community. Aboriginal people from remote groups were often suspected of being sorcerers, sometimes called 'wild blackfellows'. In the pre-European period, the fear of such beings was prompted by occasional attacks from foreign Aboriginal groups. European colonisation probably increased the fear of 'wild blackfellows' by creating categories of 'civilised' and 'uncivilised' ('wild') Aboriginal people. During the early years of European settlement in the southern districts, Aboriginal people feared 'wild blackfellows' creeping up to practice sorcery upon, or perhaps kill, them (Wilkinson 1848: 330). In the Lower Murray, Aboriginal people believed that certain celestial events foretold the coming of 'wild blackfellows' (Taplin Journals, 4–7 June 1859).

In earlier times these 'doctors' or 'sorcerers' were often people, living or dead, who were

[8] Tindale Journals, Anthropology Archives, South Australian Museum. A similar version of this account was also known by Aboriginal sources living in the South East during the 1980s.

[9] For a description of 'clever men', see Cawte (1974) and Elkin (1977).

perceived as having command over life forces and the elements of the landscape. For instance, Angas claims 'They [Lower Murray people] place great faith in sorcerers; who pretend, by charms and magic ceremonies, to counteract the influence of the spirits, to cure sickness; to cause rain and thunder, and perform other supernatural actions' (1847: 89). Sickness was generally conceived as being caused by the evil spirit of some person who had a grudge against them (Angas 1847: 96). A knowledgeable person would therefore be consulted to diagnose and correct the problem. There is a wealth of recorded material concerning the body of knowledge generally referred to in the literature as sorcery.[10] It is often difficult to separate the concepts of the healer, sorcerer and spirit being. To use exclusively any of these terms to define such people understates their role in their own culture. However, there appears to be no equivalent English term for them.[11]

In the 1980s sorcerers were generally perceived by Aboriginal people in the Lower Murray to exist only as spirit beings, not as living people or linked to anyone now deceased. They were called *kuratji* ('feather-foots') or by their original local language name, *thampamalthi*. A general fear of sorcery persisted in the community. For instance, people were careful about the disposal of their hair when it was cut, to ensure that it was not used to 'sing' them.[12] Reports of *kuratji* visitations occurred in the 1980s. For instance, according to Aboriginal people living in the South East, a *kuratji* was visiting at Woods Well on the Coorong, apparent from the 'squashed cockroach' and 'human dung' smell. Other accounts from Aboriginal people in the 1980s say the smell is *ngruwi* ('dead body fat'). The *kuratji* spirits were usually considered to be periodic visitors. When in the Point McLeay area, they were believed to stay out at quiet scrubby places, such as sections of the Block K and Gum Park farms run by the Point McLeay Aboriginal Council. Aboriginal working-men were said to be 'very careful to cover their *kantji* [urine] and *mranthin* [faeces] when out in the paddocks'. Sometimes, clearings in the bush were attributed to activities of the *kuratji*, which, in turn, were attributed to spirit beings that had 'come down from the north', possibly to punish someone. Whether sorcerers, healers and 'wild people' were human or spirit beings, what Lower Murray people knew about them in the 1980s had links to their 'traditional' pre-European past.

Witj-Witj, Witches And Devils

In southern South Australia during the 1980s, there were beliefs that some spirit creatures were once human. Such an example is the Witj-witj of the Riverland district, who reportedly was a female spirit that frightened animals away from Aboriginal hunters.[13] In her human form, she was sent away from her people for 'breaking the rules'. Another female spirit considered to be bad is associated with the Point McLeay area. Here is a place Aboriginal people call the Witches Cave in the cliffs of Big Hill facing Lake Alexandrina. Sometimes parents at Point McLeay quieten their children with threats that 'the witches will come down from Big Hill and take you away'. The Witches Cave is considered to be a dangerous place, due to the steepness of the cliff face and the friable nature of the rock. There are also other sites associated with 'bad spirits'. According to Aboriginal sources, the local name of Wirakum Point at Noonamena refers to a 'bogey man' or 'devil' (Fig.2).

The But-But Spirit

Aboriginal people in the 1980s described a being called the *but-but* as a dangerous but stupid spirit creature. It had only one arm and one leg. The 'old people' (men and women from previous generations who were knowledgeable in

[10] Most ethnographies of the Lower Murray people have some mention of sorcery practices and beliefs. For detailed accounts see Meyer (1846 [1879: 195–200]), Taplin (1874 [1879: 19,23–31]) and Berndt and Berndt (1993: 252–266).

[11] Partly for this reason, Elkin called this class of people 'Aboriginal men of high degree' (Elkin 1977).

[12] Killington (1971: 48,87) recorded from a Lower Murray person that hair was the 'trigger' on a pointing-bone, and as such was considered to have the property of being able to work into your skin, carrying with it poison. In the 1980s, some Lower Murray people believed that their own human hair, if swallowed, acted to 'spear' intestinal worms.

[13] Barney Lindsay in Education Department of South Australia (1991: 34,35) provides an account of the female spirit creature, Witj-witj. There is also a record of a male ancestor from the Murray River region with a similar name, Witjawitj (Tindale 1930–52: 303,304). These names may be derived from the European term, 'witch'.

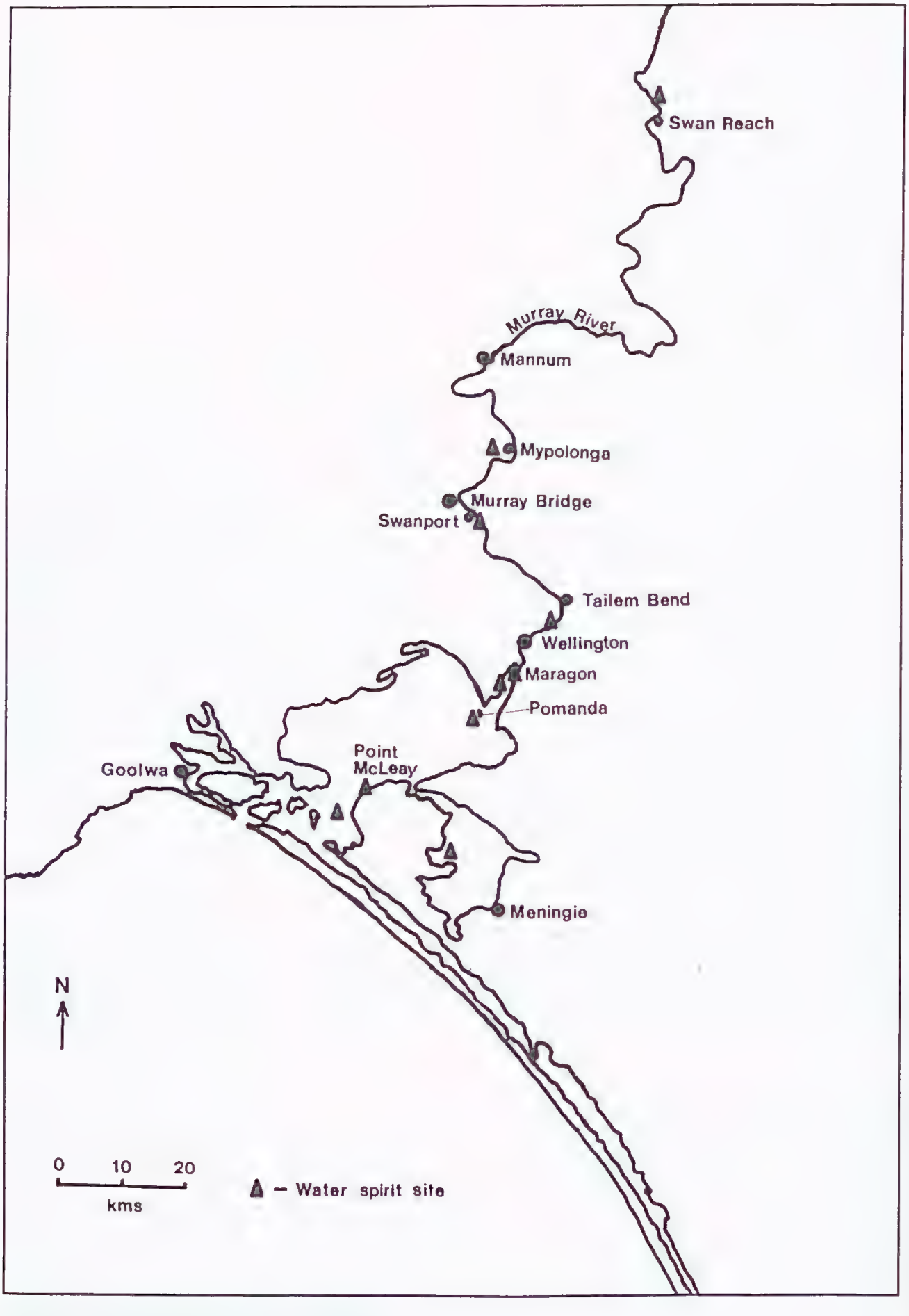

FIGURE 3. Water spirit sites in the Lower Murray.

Aboriginal tradition) apparently carried around with them bags of maggots in case *but-but* approached. If this happened, the people would lie down, putting the maggots on their eyes and mouth. This fooled the *but-but* into thinking that they were dead and passes them by. This spirit is not associated with any particular part of the landscape. The lack of sites connected with *but-but* suggests that the spirit moves randomly across the landscape, a fact that adds to its perceived stupidity.

Mulgyewonk And Other Water Spirits

Throughout south eastern Australia, there were Aboriginal accounts of water spirits, generally called 'bunyips' in the popular literature.[14] Some have been described as being animal-like, and others as predominantly humanoid creatures. In the case of the former, Aboriginal people at Moorunde near Swan Reach in the 1840s:

> believed in the existence of a water spirit, which is much dreaded by them. They say it inhabits the Murray; but although they affirm that its appearance is of frequent occurrence, they have some difficulty in describing it. Its most usual form, however, is said to be that of an enormous star-fish (Angas 1847: 97,98).

All reports by Aboriginal people in the Lower Murray feature a more humanoid-type of spirit than that recorded above (Fig.3).[15] They called the 'bunyip' of the Lower Murray, the *mulgyewonk*. This class of water spirit was greatly feared. The booming noises it made were thought to cause rheumatism (Taplin 1874 [1879: 62]). Taplin records:

> The blacks say that the Moolgewanke [*mulgyewonk*] has power to bewitch men and women and that he causes disease by the booming noise which he makes. I am now convinced that the noise does come from the lake. They say that Mr Mason shot at one over on Pomont [Pomanda] and it made him ill afterwards by its power. They say he is very much like a pungari (seal) but has a face with a menake (beard) like a man (Taplin Journals, 2–3 July 1860).

The consistent theme of most descriptions of its behaviour was the threat of capturing children who strayed too close to the edge of the lake. A Yaraldi informant, Mark Wilson, said that the *mulgyewonk* would lie submerged in the shallow waters near the edge of the lake waiting for human victims.[16] He said that its long trailing hair in the water looked like waterweed. The smell of fish and duck grease, especially when children are washing their hands in the lake after a meal is said to attract the *mulgyewonk* (Berndt & Berndt 1993: 203). Taplin was told that a man, who had rubbed himself over with oil, descended by a rope to the bottom of the lake to rescue a child captured by the *mulgyewonk* (Taplin Journals, 16–17 September 1862).[17] He managed to drag the child out from amongst the *mulgyewonk*, who were sleeping, and get back safely. Even Ngurunderi, the main Dreamtime creator of the region, was not immune to the nuisance caused by this water spirit. At the Murray entrance to Lake Alexandrina, a *mulgyewonk* tore holes in his nets, which prevented him fishing for his family (Tindale & Pretty 1980: 50). All reports of the *mulgyewonk* reinforced it as a symbol of the dangerous nature of the waters in the Lower Lakes and Murray River region.

One European resident who lived near Narrung described an incident in the 1950s or 1960s when some Aboriginal children ran to her saying there was a *mulgyewonk* in the lake. She later heard that it turned out to be a floating tree trunk with its trailing roots partially out of the water. Apparently the children had remembered their parents' warnings about the lake and the water spirit. Children are associated with both the

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[14] A general description of 'bunyip'-type water spirits is given in the *Observer*, 2 December 1893. See also Barrett (1946), Massola (1957), Hemming (1985), Ramson (1988: 109), Cameron-Bonney (1990: 16,17), Mulvaney (1994) and Smith (1996).

[15] The wormlike models of 'bunyips' that presently make up a coin-operated tourist attraction in Sturt Reserve at Murray Bridge are looked upon with disgust by many local Aboriginal residents, mainly because they do not look correct according to their own descriptions.

[16] 'The Moolgewauk' by Mark Wilson, Fry Papers, Anthropology Archives, S.A. Museum (Published in the *Journal of the Anthropological Society of South Australia*, March 1985, **23**(1): 11–16). Mark Wilson was a Yaraldi man.

[17] A closely related report is given in Wilson (cited above). See similar accounts given by Tindale (1930–52: 269,270), Berndt (1940a: 168), Rankine (in Isaacs 1980: 114; 1991: 121–123), and Berndt and Berndt (1993: 203,204). They all record that a boy is taken by *mulgyewonks* to live underwater. In a version published in a teaching manual (Education Department of South Australia 1991: 24,25); a man fishing is attacked by a *mulgyewonk*.

general story and many of the sightings. For example, in 1870, George Taplin's own son claimed to have seen the *mulgyewonk* in the lake (Linn 1988: 52).

It is likely that mounds of vegetation and earth trapped in the lake have resulted in some *mulgyewonk* 'sightings'. Before the building of the barrages, when seasonal fluctuations in the flow of the river into the lakes were much greater, large amounts of material were to be found floating there.[18] For instance, Angas says:

> Floating islands, covered with reeds, are frequently to be seen on this [Murray] river. These masses of earth, originally detached from the banks by floods or otherwise, are frequently drifted from side to side, and not a few find their way to the lake (Angas 1847: 54).

Aboriginal people reported to Taplin that they had seen the *mulgyewonk* and that one of them had died and rotted close to the shore of the lake near Rankine's ferry (Taplin Journals, 16–17 September 1862). It is interesting to note that Aboriginal people at Point McLeay during George Taplin's time attributed the booming sound of the lake to the *mulgyewonk* breaking up gumtrees, which eventually floated down the Murray (Taplin Journals, 20 June 1860). Some of these *mulgyewonk* noises were probably caused by the sudden expulsion of mud under shifting sand in the Coorong.[19] Rather than claiming that the cultural experience of the *mulgyewonk* resulted from a misinterpretation of the environment, the earlier flow conditions in the Lower Lakes and Murray River would probably have promoted more 'sightings' than now possible.

Fieldwork in the 1980s has shown that Aboriginal people associated certain sites in the river and lakes with the *mulgyewonk*. Perhaps the most widely known in the Aboriginal community was the site of George Mason's former depot on the eastern banks of the Murray, near the opening of the river into Lake Alexandrina. This place, called Maragon, was the site of many of the oral history accounts of *mulgyewonk* encounters during the last hundred years (Fig.3). Bubbles seen in the water here were considered to be proof of their existence. Several Aboriginal sources stated that there are rock holes under the cliffs at Maragon beneath the water level where these spirits lived. Understandably, for Aboriginal people swimming was not allowed at this spot. Mark Wilson's account cited above lists both Maragon and the cliffs of Pomond (Pomanda), about 8 kilometres to the south, as underwater homes for colonies of the *mulgyewonk*. Local Aboriginal people passing in canoes at night avoided the latter place, said to be their 'headquarters'. Another possible *mulgyewonk* site is Mypolonga, about 15 kilometres up river from Murray Bridge. Albert Karloan considered that this place name was possibly derived from the term *mulgyewonk* (Berndt 1940a: 166).

The *mulgyewonk* was also considered to have existed in Lake Albert and Lake Alexandrina waters. According to oral history among local European families, another site associated with this water spirit is the arm of Lake Albert. A member of a local European family claimed that Aboriginal groups for this reason avoided the area. At Point McLeay, some Aboriginal people in the 1980s remembered earlier times when the *mulgyewonk* was reportedly encountered in Lake Alexandrina. For instance, sometime during the 1940s, several elderly women, who had been fishing at the base of Big Hill at Point McLeay, hurried back to the settlement saying they had heard a *mulgyewonk* splashing a short distance into the lake. This spirit appears to have been perceived as located in all the permanent waterways of the Lower Murray (Fig.3). In the 1980s Aboriginal people in the Riverland considered that a hole in the cliff face near the site of a former mission station at Swan Reach was also the home of a *mulgyewonk*.[20] In 1952,

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[18] Aboriginal informants have pointed out several large and weathered tree trunks of dead red gums lying along the shores of Lake Alexandrina. These tree sections, of a tree species not found in this part of the Lower Murray shore, were left behind after the 1956 flood. See Hemming and Jones (1989: 1) for a photograph of one such tree trunk at 'The Bullrushes'.

[19] The water origin of the booming noise appears certain. Taplin records in his Journals (26 June 1860) that he was convinced that the booming sound originated from in the lake. He heard it 12 times in 10 minutes one evening (Journals, 20 June 1860). See other accounts by Taplin (*Register*, 30 January 1862; 1874 [1879: 62,63]). Tindale puts forward a physical explanation of the origin of the booming sound (*Advertiser*, 12 May 1936). It is possible that the advent of frequent mechanical noises in the Lower Murray, such as gun blasts, quarry activity etc., has hidden this phenomenon. Also, it is likely that the barrages at the Murray Mouth and Coorong have altered the conditions that produced the booming effect.

[20] This term is recorded in the early Lower Murray languages. Nevertheless, the term has had much wider use since European settlement. For example, a paddle steamer, based at the Goolwa end but working along the Murray River in the 1860s, was named after the river spirit, being called the 'Moolgewanke' (Taplin Journals, 26 November 1862).

Joe Mason, from the Nganguruku people, considered that the river spirit, that he called the *muldjewangk,* still lived along the Murray River at Ranginj (Devon Downs). He claimed 'I reckon it weighs 150 pounds [68 kilograms] in weight. It makes ripples on the water when it swims' (Tindale 1930–52: 313). The use of the name for this spirit here possibly reflects the movement of Aboriginal people from the Lower Murray area to the Riverland after European settlement.

Most Aboriginal people during the 1980s who claimed to have previously seen or heard the *mulgyewonk* were people who had lived at Maragon. One such man stated that he and his family observed a *mulgyewonk* in the river while they were driving across the Swanport Bridge near Murray Bridge several years earlier. This same person claimed to have found a deep hole along the edge of Lake Alexandrina when he was younger. A foul stench and a whooshing noise came from it. After describing it to his father, he was told to keep away from this area, as it was the home of the *mulgyewonk*. Another Aboriginal source claimed 'Old fellas say that whirl pools are made by *mulgyewonks* cleaning their houses.' Although the *mulgyewonk* is sometimes reportedly seen in the Lower Murray, several Aboriginal sources of this century have said it is either extinct or at least very scarce. Mark Wilson (cited above) thought that the arrival of paddlesteamers and other boats on the river caused their destruction. This opinion was reinforced by Henry Rankine from Point McLeay who gave an account of a violent encounter between a river boat captain and a *mulgyewonk* (Rankine 1991: 122). Some Aboriginal people expressed opinions that the *mulgyewonk* was a 'prehistoric remnant', and 'like the Loch Ness monster'. This water spirit was a talking point in many Lower Murray families during the 1980s.

Although the *mulgyewonk* was the main water spirit in the Lower Murray, there were also some lesser known beings. From an Aboriginal person came the following account:

> The three sisters live in the lake [Lake Alexandrina] just out from Loveday Bay. They are bad. When you are in a boat there, the first wave pushing the boat so it points the wrong way. The second makes the edge dip. The third wave fills the bottom and turns it upside down.[21]

This story was told as proof about the dangerous waters of the lake, particularly near the islands at the Murray Mouth. Several examples of white fisherman and canoeists drowning in the region were given as additional evidence. All of the information on Lower Murray water spirits reinforces the danger element of human activity on or near the waterways. This expresses the Aboriginal perception that some areas of their landscape are not safe.

Bird Spirits

Birds of one kind or another featured prominently in much of the Lower Murray mythology. In the pre-European world view of the Aboriginal people, many bird species were probably perceived as travellers between the cosmic and terrestrial landscapes, due to their ability to fly. In an early description of a spirit bird, Penney uses the term, 'muldaubie', which is a generic term for bad spirit. Penney says:

> They believe that he appears at night when the moon is up, in the evening or just before the dawn of day, in the form of the screech-owl, although he assumes occasionally other appearances. Those to whom he appears in dreams or who see his form almost infallibly die.[22]

The screeching of the 'night-owl' was considered by Lower Murray people to be a sign that something was wrong (Ramsay Smith 1930: 322). This is consistent with early Aboriginal beliefs in western Victoria where owls were considered to be used by an evil spirit to watch over people who had strayed from the camp during the night (Dawson 1881: 49,52,53). The southern stone-curlew (*Burhinus grallarius*) too, appears to have been an omen for death across southern Australia (Berndt 1940b). To Yaraldi people, hearing the call of this bird at night foretold the death of a close relative (Berndt 1940b: 460,461). Although it was no longer heard in the Lower Murray region during the 1980s, Aboriginal people could remember hearing the southern stone-curlew's call along the Coorong in the 1950s and being told that it was an ill omen.

During fieldwork, the bird spirit most commonly spoken about in the Lower Murray was the '*mingka*-bird'. The *mingka* was essentially a

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[21] Clarke (1994: 135).

[22] Penney (as 'Cuique') in *South Australian Magazine*, June–July 1842: 389–394.

night time spirit. According to one report, there were two forms of this spirit, a northern and a southern type. The northern one lived in a cave at Mount Barker. Although it ranged far, including into the south, the *mingka* returned there each night. It was described by another source as a 'sphinx-like bird', which had a human head. It came around houses at night, making a noise like a baby crying. Some people said the *mingka* could also sound like a fox. One Aboriginal account described the call as a 'shrill whistle'. Like many of the spirits already mentioned, it was a commonly used threat to make children behave. According to Tindale's Potaruwutj informants from the South East, the '*Minkar* bird is an evil being, warns about death or trouble.'[23]

It was claimed in the 1980s that in the past some old men could turn into a *mingka* at will. In the South East, an Aboriginal 'doctor' named Old Jumbuck was said to have fought with a *mingka*-bird at Bordertown. During the fight the spirit-bird repeatedly changed form, from a bird to a human, until it eventually escaped. It was reported that only Aboriginal 'doctors' could do this. One young adult explained, 'If you kill a *mingka*-bird, you must burn all of its feathers. As each feather can grow into another *mingka*-bird. It is like a phoenix in this way.' The *mingka* was said to punish people who had done something wrong. One man, it was stated, lost all but two of his children to a *mingka*-bird as 'tribal punishment'. As with the *mulgyewonk*, children appeared to be perceived as most at risk to this spirit. Children doing forbidden things at night such as crying, whistling, or even putting such objects as hats or toys on their head, was thought to possibly cause a visit by a *mingka*-bird. The spirit bird was also an omen creature. There were several accounts of people hearing the *mingka* during the night, and then being told of the death of a close friend or relative the next day. On one occasion in the 1950s it was heard calling in the scrub adjacent to a Coorong fringecamp. It thrashed about in the dark, while everybody kept inside. The next day, the children found several tops of trees, measuring over 5 cms in diameter, which had been snapped off during the night. One person claimed that her grandmother had once talked to a *mingka*-bird, which had the head of her husband's recently dead grandfather. In most accounts of this spirit it was thoroughly evil. It 'will steal a baby's breath if it hears one crying'. The 'breath' here was understood by Aboriginal sources to be the infant's spirit. The association of this bird with death was strong in all accounts.

Although the home of the *mingka*-bird was said to be Mount Barker, it was reported as seen and heard at settlements throughout the Lower Murray. Furthermore, it was said that the spirit could potentially be encountered anywhere that Lower Murray people lived. At Point McLeay, it was sometimes heard in trees on the settlement. Here, particular clumps have been pointed out as favourite roosts, such as those near the cemetery. Outside the Lower Murray area, this spirit was apparently heard in the Riverland of South Australia and one was reported as seen by a Lower Murray person whilst living in Victoria. In the 1980s, the association of the *mingka* with Lower Murray people was strong, so much so that it was virtually never mentioned in any context other than its unwanted attraction towards these people.

There are various Aboriginal names for this spirit: *mingka* was said to be a Potaruwutj language term from the South East and *merambi* the Tangani word from the Coorong (Tindale 1931–34: 228,229).[24] In the 1980s the Lower Murray name was stated to be *kowuk*, and it was described as a tawny frogmouth (*Podargus strigoides*). The spirit was also recorded as being able to assume the guise of various *ngaitji* (totemic 'friends'), such as an eagle, dog or hawk (Tindale 1931–34: 228,229). In these forms, the *mingka* carried the spirits of sinister beings, connected to their owners by *nunggi* or *kortui* described as 'like a spider web'. Men could kill these beings and the owners of the attending spirits with a 'sacred club'. Berndt suggested that the *mingka* was an owl (Berndt 1940b: 461). A Lower Murray person recorded by Killington stated that this spirit was the 'frogmouth owl' (Killington 1971: 49,50,88). Tindale said that *minkar* was the name for both the wedge-tailed eagle (*Aquila audax*) and the white-breasted sea eagle (*Haliaeetus leucogaster*) in the Potaruwutj language of the Tatiara region (cited in Condon 1955: 84). The association of large birds of prey with carrying the spirits of the dead was a common belief across Australia (Clarke 1991: 65). The Skyworld was perceived by Aboriginal

[23] Tindale vocabulary cards for the Potaruwutj of the South East (Anthropology Archives, S.A. Museum).

[24] The Tindale vocabulary cards for the Potaruwutj of the South East (Anthropology Archives, S.A. Museum) lists *minkar* as a 'being, sinister, who may assume form of totem animal.'

groups of southern South Australia as a cosmic landscape where many of the constellations were bird spirits who had travelled there from the lower land (Clarke 1996).

The association of birds of prey with the power of foresight and as vehicles for spirits is not always expressed negatively. For instance, a 1980s account states that an Aboriginal man, named Joe Lock, who had lived at the Blackford Aboriginal Reserve in the South East earlier in the twentieth century, was able to turn his 'spirit' into an eagle. One day, reportedly after he had flown about as an eagle, he was able to accurately describe a group of people travelling to the Blackford Reserve in a horse and buggy, long before they arrived. While his spirit was an eagle, his living body, which was left lying on a blanket, was not moved. In another version, it was an eaglehawk that Lock turned into while his human body was under a blanket (Berndt & Berndt 1993: 249,250). These accounts, and that of the *mingka*-bird above, indicate that Aboriginal people perceived some birds as being a vehicle for the human soul.

The *Ngout-ngout* was an individual spirit associated with birds.[25] She was reportedly once a woman who was expelled from her local group for breaking custom. For revenge, *Ngout-ngout* tricked children into becoming lost. This she achieved by using a trail of flowers to distract them. *Ngout-ngout* could turn into a bird. This story was told to children with the warning that they never wander off.

Some bird species commonly seen during the day have a similar role to the *mingka* as omens. In the Lower Murray during the 1980s the most commonly held belief in omens concerned the willie wagtail (*Rhipidura leucophrys*), *ritjaruki*. When this bird was observed persistently making strange erratic movements near a person's house, it was perceived as a message that someone had died. Tapping on a window was taken as a particularly bad sign. A variation of this belief was that when a *ritjaruki* is observed with a rusty colour on its beak, this means someone would die. One elderly Lower Murray woman living at Point McLeay in the 1980s said '*Ritjaruki*. Him good telephone at Raukkan that fella.' There were many examples of observations of the *ritjaruki* being used to forecast human death. The negative influence of the bird was made apparent when a young man at Point McLeay was said to have behaved recklessly after having accidentally run over and killed a *ritjaruki*. Since its omens were invariably considered to be unwanted, the bird was sometimes chased away. In the Lower Murray during the 1840s for instance:

> An elegant species of flycatcher, of a black colour, which continually hovers about in search of insects, performing all manner of graceful manoeuvres in the air, is regarded by them as an evil spirit, and is called mooldtharp, or devil. Whenever they see it, they pelt it with sticks and stones, though they are afraid to touch or destroy it (Angas 1847: p.96).

The ability of this bird to summon bad news appears to have been widespread elsewhere in southern Australia.[26] It is likely that the attention the willie wagtail attracts from its highly energetic movement across low and open areas, such as around houses and cars, added to the likelihood of this species being used as an omen.

There are other examples of birds being used to predict death. For instance, one Aboriginal person in the 1980s said that her mother's *nga:tji* (totemic 'friend'), a swallow (probably *Hirundo neoxena*), would fly up close to them and 'sob like a child' if someone close was dying.[27] It is likely that in earlier times, totemic species and objects would have been considered to have the power to warn people of danger or death. Another account sometimes told at Point McLeay involved a pelican, *nguri* (*Pelecanus conspicillatus*). Sometime before the 1970s, when Point McLeay was still the Government Mission Station, an Aboriginal man was out hunting near Narrung. He observed a pelican flying overhead and he

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[25] An account by Barney Lindsay is given in Education Department of South Australia (1991: 18,19). The relationship between this female spirit and male human spirits such as *Ngautngaut* of Devon Down (Tindale 1930–52: 303,304) and *Ngout-Ngout* of western Victoria (Massola 1968: 20,21) is not clear.

[26] For instance, on Yorke Peninsula, the willie wagtail was also considered to be a 'message-carrier' (Ramsay Smith 1930: 342). In the 1980s, a western Victorian Aboriginal person said that they also considered the willie wagtail to be a bad omen there. She knew of two occasions where people had reportedly died soon after seeing this bird tapping on their window. A Lower Murray informant claimed that the willie wagtail, called by them 'tjiri tjiri', as an omen, was a belief from the Portland district of Western Victoria (Killington 1971: 49,50,82).

[27] For an outline of 'nga:tji', see Meyer (1843(2): 86; 1846 [1879: 198]), and Taplin (1874 [1879: 1]; 1879: 131).

raised his gun to shoot it. Pelican flesh is considered bad eating but the feathers were used in ornament making. Nevertheless, the bird was acting strangely so it was not shot. The pelican flew several times over the man's head and then out over Point McLeay and across the lake towards Adelaide. This was interpreted as a message that the man's brother, who was known to be in an Adelaide hospital, had just died. The story concludes with the later surprise of the Mission superintendent, who had come down to the man's house with the message of the death, at being told the family already knew.

The ability of birds to fly and the more frequent observation of them made them more suitable than other land-based animals as omens. The specific behaviour of certain species, such as the willie wagtail, seems to have been a major factor in their designation as message carriers. The night time activity or the ability to fly high were probably important characteristics in the identity of other spirits. For other birds, peculiar behaviour on single occasions was interpreted as a sign. Although much of the folklore formerly known by Aboriginal people was lost or significantly altered by the 1980s, the Aboriginal practice of seeking information from signs in the environment persisted.

Cultural Significance Of Spirit Beings

The Aboriginal cultural landscape of the past was imbued with meaning, not just with the topographical reminders of the actions of creative 'Dreamtime' ancestors, but by the perceived occupation of spirits. As with biotic organisms, such as plants and animals, these beings were considered to exhibit particular spatial behaviours. With a few exceptions, the spirits exhibited their own territoriality. The beliefs in spirit beings contain encoded knowledge about the landscape, particularly about dangerous places and the movements of human spirits after death. Many of the accounts given in this paper either relate directly to children, or concern the actions of beings that could be used as threats by adults to help control the behaviour of them. Other spirits served as omens, providing a means by which Aboriginal people could make predictions on the future. Fundamental to many of the beliefs is the Aboriginal notion of a person's spirit surviving death and being able to be summoned and carried away by spirits. In some contexts, most of the spirits discussed in this paper could be termed as *mu:ldapi*, stressing their potentially negative impact upon the lives of Lower Murray people.

Twentieth century Aboriginal culture in southern Australia has often been described in sociological rather than cultural terms. There are nevertheless elements of the pre-European world view that have persisted here. During the 1980s, beliefs in spirits, albeit in greatly modified form, served to 'explain' the rural landscape in a manner that relates to how they probably explained the pre-European landscape. Aboriginal people also derived some enjoyment in these beliefs as stories. They were also important as signifiers used by Aboriginal people in the Lower Murray to express their regional identity. By engaging in the discussion of the activities of spirits as fellow occupants of their land, Aboriginal people were highlighting their identity with respect to the local landscape.

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References

ANGAS, G. F. 1847. 'Savage Life and Scenes in Australia.' Smith, Elder & Co., London.

BARRETT, C. 1946. 'The Bunyip.' Reed & Harris, Melbourne.

BERNDT, C. H. 1989. Retrospect and prospect: looking back after 50 years. In P. Brock (ed) *Women, Rites and Sites: Aboriginal Women's Cultural Knowledge.* Pp.1–20. Allen & Unwin. Sydney.

BERNDT, R. M. 1940a. Some aspects of Jaraldi culture, South Australia. *Oceania*, **11**(2): 164–185.

BERNDT, R. M. 1940b. A curlew and owl legend from the Narunga tribe, South Australia. *Oceania*, **10**(4): 456–462.

BERNDT, R. M. 1989. Aboriginal fieldwork in South Australia in the 1940s and implications for the present. *Records of the South Australian Museum*, **23**(1): 59–68.

BERNDT, R. M. & C. H. 1951. 'From Black to White in South Australia.' Cheshire, Melbourne.

BERNDT, R. M. & C. H. 1989. 'The Speaking Land.' Penguin, Melbourne.

BERNDT, R. M. & C. H., with STANTON, J. E. 1993. 'A World That Was. The Yaraldi of the Murray River and the Lakes, South Australia.' Melbourne University Press at the Miegunyah Press, Melbourne.

BERNDT, R. M. & VOGELSAND, T. 1941. Comparative vocabularies of the Ngadjuri and Dieri tribes, South Australia. *Transactions of the Royal Society of South Australia* **65**(1): 3–10.

CAMERON-BONNEY, L. 1990. 'Out of the Dreaming.' *South East Kingston Leader*, Kingston.

CAWTE, J. 1974. 'Medicine is the Law.' University Press of Hawaii, Honolulu.

CLARKE, P. A. 1991. Adelaide as an Aboriginal Landscape. *Aboriginal History*, **15**(1): 54–72.

CLARKE, P. A. 1994. 'Contact, Conflict and Regeneration. Aboriginal Cultural Geography of the Lower Murray, South Australia.' Ph.D thesis. University of Adelaide: Adelaide.

CLARKE, P. A. 1995. Myth as history: the Ngurunderi mythology of the Lower Murray, South Australia. *Records of the South Australian Museum*, **28**(2): 143–157.

CLARKE, P. A. 1996. The Aboriginal cosmic landscape of southern South Australia. *Records of the South Australian Museum*. **29**(2): 125–145.

CONDON, H. T. 1955. Aboriginal bird names – South Australia. part 1. *South Australian Ornithologist*, July 1955, pp.74–88.

DAWSON, J. 1881. 'Australian Aborigines.' Robertson, Melbourne.

EDUCATION DEPARTMENT OF SOUTH AUSTRALIA. 1991. 'The Kai Kai Nature Trail: A Resource Guide for Aboriginal Studies.' Aboriginal Studies R-12. Education Department of South Australia, Adelaide.

ELKIN, A. P. 1977. 'Aboriginal Men of High Degree.' Second edition. University of Queensland Press, St Lucia.

GALE, F. 1972. 'Urban Aborigines.' Australian National University Press, Canberra.

HARVEY, A. 1939. Field Notebook. Fry Collection, South Australian Museum Anthropology Archives, Adelaide.

HEMMING, S. J. 1985. The Mulgewongk. *Journal of the Anthropological Society of South Australia*, **23**(1): 11–16.

HEMMING, S. J. 1988. Ngurunderi: a Ngarrindjeri Dreaming. *Records of the South Australian Museum* **22**(2):191–193.

HEMMING, S. J. & JONES, P. G. with CLARKE, P. A. 1989. 'Ngurunderi: an Aboriginal Dreaming.' South Australian Museum, Adelaide.

ISAACS, J. 1980. 'Australian Dreaming: 40,000 Years of Aboriginal History.' Lansdowne Press, Sydney.

KILLINGTON, G.M. 1971. 'A Preliminary Survey of the 'World View' of Urban Aboriginal People Participating in the Community Development Program of the Port Adelaide Central Mission.' University of Adelaide, Adelaide.

LINN, R. 1988. 'A Diverse Land: a History of the Lower Murray, Lakes and Coorong.' Meningie Historical Society, Meningie.

MASSOLA, A. 1957. The Challicum bun-yip. *Victorian Naturalist*, **74**: 76–83.

MASSOLA, A. 1968, 'Bunjil's Cave. Myths, Legends and Superstitions of the Aborigines of South-East Australia.' Lansdowne, Melbourne.

McENTEE, J. C. & McKENZIE, P. 1992. 'Adna-mat-na - English Dictionary.' Authors, Adelaide.

MEYER, H. A. E. 1846. 'Manners and Customs of the Aborigines of the Encounter Bay Tribe, South Australia.' Reprinted in Woods, J.D. (ed) 1879. 'The Native Tribes of South Australia.' E.S. Wiggs, Adelaide.

MOUNTFORD, C. P. 1958. 'The Tiwi: Their Art, Myth and Ceremony.' Phoenix House, London.

MULVANEY, J. 1994. The Namoi bunyip. *Australian Aboriginal Studies*, no.1: 36–38.

RAMSON, W. S. (ed). 1988. 'The Australian National Dictionary: a Dictionary of Australianisms on Historical Principles.' Oxford University Press, Oxford.

RANKINE, H. J. 1991. A talk by Henry Rankine. *Journal of the Anthropological Society of South Australia*, **29**(2): 108–127.

SMITH, M. 1996. 'Bunyips and Bigfoots. The Search of Australia's Mystery Animals.' Millennium Books, Sydney.

SMITH, W. RAMSAY 1930. 'Myths and Legends of the Australian Aboriginals.' Harrap, Sydney.

TAPLIN, G. 1859–79. Journals. Mortlock Library, Adelaide.

TAPLIN, G. 1874 [1879]. The Narrinyeri. In Woods, J.D. (ed)'The Native Tribes of South Australia.' E.S. Wiggs, Adelaide.

TAPLIN, G. 1879. 'Folklore, Manners, Customs and Languages of the South Australian Aborigines.' South Australian Government Printer, Adelaide.

TINDALE, N. B. no date. 'Notes for Little People' Anthropology Archives, South Australian Museum.

TINDALE, N. B. 1930–52. 'Murray River Notes.' Anthropology Archives, South Australian Museum.

TINDALE, N. B. 1931–34. 'Journal of Researches in the South East of South Australia.' Vol.1. Anthropology Archives, South Australian Museum.

TINDALE, N. B. 1936. Notes on the natives of the southern portion of Yorke Peninsula, South Australia. *Transactions of the Royal Society of South Australia*, **60**: 55–70.

TINDALE, N. B. & PRETTY, G. L. 1980. The surviving record. In Edwards, R. & Stewart, J. (eds) 'Preserving Indigenous Cultures: a New Role for Museums.' Australian Government, Canberra.

WILKINSON, G. B. 1848. 'South Australia: its Advantages and Resources...' London.

'FINCH' VERSUS 'FINCH-WATER': A STUDY OF ABORIGINAL PLACE-NAMES IN SOUTH AUSTRALIA

LUISE A. HERCUS AND VLAD POTEZNY

HERCUS, L. A. & POTEZNY, V. 1999. 'Finch' Versus 'Finch-Water': A Study of Aboriginal Place-Names in South Australia. *Records of the South Australian Museum* **31**(2): 165–180.

This paper discusses the causes that underlie the geographical distribution of names ending in -owie and similar water-related place-names. The authors draw on the place-name research of N. B. Tindale and on their own fieldwork, and correlate the place-naming conventions in South Australia with the known linguistic data. They suggest broad conclusions relating to linguistic development and diffusion within the region. The patterning of water-related place-names suggests that linguistic diffusion has interrelated with, and in many instances overcome, the strongest genetic links.

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Introduction

Finches love to congregate around water, and so it is not surprising to find sources of water called after them. The best known of these is Ediowie *Idhi-awi*[1] 'Finch-water' in the Flinders Ranges. Further north on the western side of Lake Eyre in Arabana country there are two places simply called *Yatyapara-nha* 'Finch': the final *-nha* is the optional proper noun marker used in Adnyamathanha, Kuyani, Arabana and other languages to the north. One *Yatyapara-nha* is the Tarlton spring near the headwaters of Hope Creek, the other is Lethbridge Spring, near the Paisley Creek, and hence the name serves also for the Paisley Creek. There is at first sight nothing remarkable about this, except that on closer investigation we find that there are simply no place-names ending with the word for 'water' in Arabana country, nor in the areas where Diyari and closely related languages were once spoken. Place-names follow the pattern of 'Finch' or 'Finches' (no distinction is made between singular and plural unless this is to be emphasised), rather than the 'Finch-water' of the more southerly areas. In this paper we attempt to show the extent of this regional distinction and to examine further implications. The names under discussion only represent a fraction of the totality of place-names in the area, because throughout there are many names that are not descriptive at all. Place-names can be formed in all kinds of ways and may even consist of verb-forms referring to events in myths. An example of such a name from Wirangu country is 'Cungena', the name of a small railway township to the east of Ceduna, based on an original *Wiyana-gandyina* "(they) kept hold of the woman'; *gandyina* is the past tense form of the verb *gandyirn* 'to keep hold of'. Although the descriptive names for sources of water are definitely not the rule and do not represent the whole picture, they do nevertheless give some linguistic insights. N.B. Tindale's own manuscript notes suggest that he was intrigued by the distribution of the 'awi' place-name suffix as long ago as the 1930s. In fact, this interest may have been a contributing factor to his enduring research interest in Aboriginal place-names, which continued until his death in 1993.

In the part of South Australia that we are discussing there is one major closely linked language sub-group. These are the Thura-Yura languages, from the word for 'man' in some of them. These languages are listed here, with a rough indication of their location, based on Tindale 1974.[2]

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[1] Words that are based on modern linguistic transcriptions are given in italics.

[2] This paper is not intended to make any detailed statement regarding the attribution of country to one group or another: it deals with the formation of names.

Kaurna	Adelaide area.
Narangga	Yorke Peninsula.
Ngadyuri	Peterborough area.
Nukunu	Southern Flinders Ranges, and from Crystal Brook to Port Augusta.
Parnkalla	Eyre Peninsula and adjacent areas to the north.
Nauo	Southern Eyre Peninsula.
Adnyamathanha	Northern Flinders Ranges.[3]
Walypi	Blinman area, closely associated with Adnyamathanha.
Kuyani	the plains to the west of the Flinders Ranges and Stuart Creek country.

an outlier of this subgroup is:

Wirangu	on the West Coast of South Australia and originally inland beyond the railway line.

Nearly all the Thura-Yura languages use the 'Finch-water' type of place-name.

To the north of this area languages of the Karnic subgroup were spoken: these include Arabana from the west side of Lake Eyre, Thirrari, Diyari, Pirlatapa, Yandruwantha and Yawarawarrka from the Cooper and the far north-east of the state. The language spoken to the east of the Northern Flinders Ranges was Yardliyawara: this was closely related to Wadigali from the Yandama Creek and to Malyangapa in adjoining parts of New South Wales. Further south were Wilyakali and Thangkali, which belong to Paakantyi, the Darling River language group. All these languages use the 'Finch' type of place-name. The word for 'water' is never added to the end of a place-name, not even optionally. Within South Australia it is basically the Northern Flinders Ranges and an area from the Western Australian border to Olary that contains numerous place-names of the 'Finch-water' type.

-Awi 'Water'

In Adnyamathanha country

The word for 'water' in the Thura-Yura languages is *kawi,* but when this is added to another word to form a place-name the initial *k* of *kawi* is usually lost. In the Adnyamathanha language of the Northern Flinders Ranges initial *k* is lost altogether, and 'water' is '*awi* ' anyway. The final vowel of the preceding word is usually lost before *-awi* : this seems to be the case even with *-i*[4] and *-u* , eg. *Wartuli-awi* >*Wartul-awi.* This rule applies in Parnkalla and Nukunu too, hence Marachowie 'Marrity'awi' from 'marrityi + awi' and Tandowie 'Thand'awi' from 'thandu+ awi'. There are some exceptions which will be noted in the relevant sections. The term *-awi,* usually rendered as 'owie' in English spelling, appears to be used at the end of many, though by no means all relevant place-names as a kind of classifier, showing that the locality is a source of water, or associated with a source of water; so a creek or even a nearby hill can be named from a spring or waterhole.

The use of *-awi* in place-names is most conspicuous in the Northern Flinders Ranges in Adnyamathanha country. Some of the names of springs or soakages (now often made into bores and wells) in the Flinders have names ending in *-awi.* These names are numerous and we give just some examples. The explanations, unless stated otherwise, are all based on McEntee and McKenzie (1992) and on personal communications from John McEntee:

Italowie Creek, Gorge and Spring *Itarl'awi,* from *itarla* 'a crack in rocks'; in the Gammon Ranges.

Wilkowie Well	*Wilk'awi* 'Dog Water'; just north of the Flinders, on the Strzelecki Track.
Arrowie Spring	*Arr'awi, Arr'awi-nha,* 'High Water' (McEntee & McKenzie 1992: 11), but Tunbridge 1988: 98 analyses this as *Arru-awi;* north of Mt Chambers.
Weetowie Waterhole	*Urt'awi,* 'Black Tea-tree Water; close to Arrowie, north of Mt Chambers'.
Wirrapowie Spring	in Bendieuta Creek, possibly *Wirup'awi;* 'Cockatiel Water' (J. McEntee, pers.com.).

[3] Tindale (1974) uses the name 'Wailpi' for all the people of the Flinders Ranges.

[4] There do not appear to be any Adnyamathanha, Nukunu or Parnkalla examples of a final *-i* in disyllabic words preceding *-awi*; there is however the nearby case of Busheowie (see under Kuyani below). We use an apostrophe to indicate vowel elision.

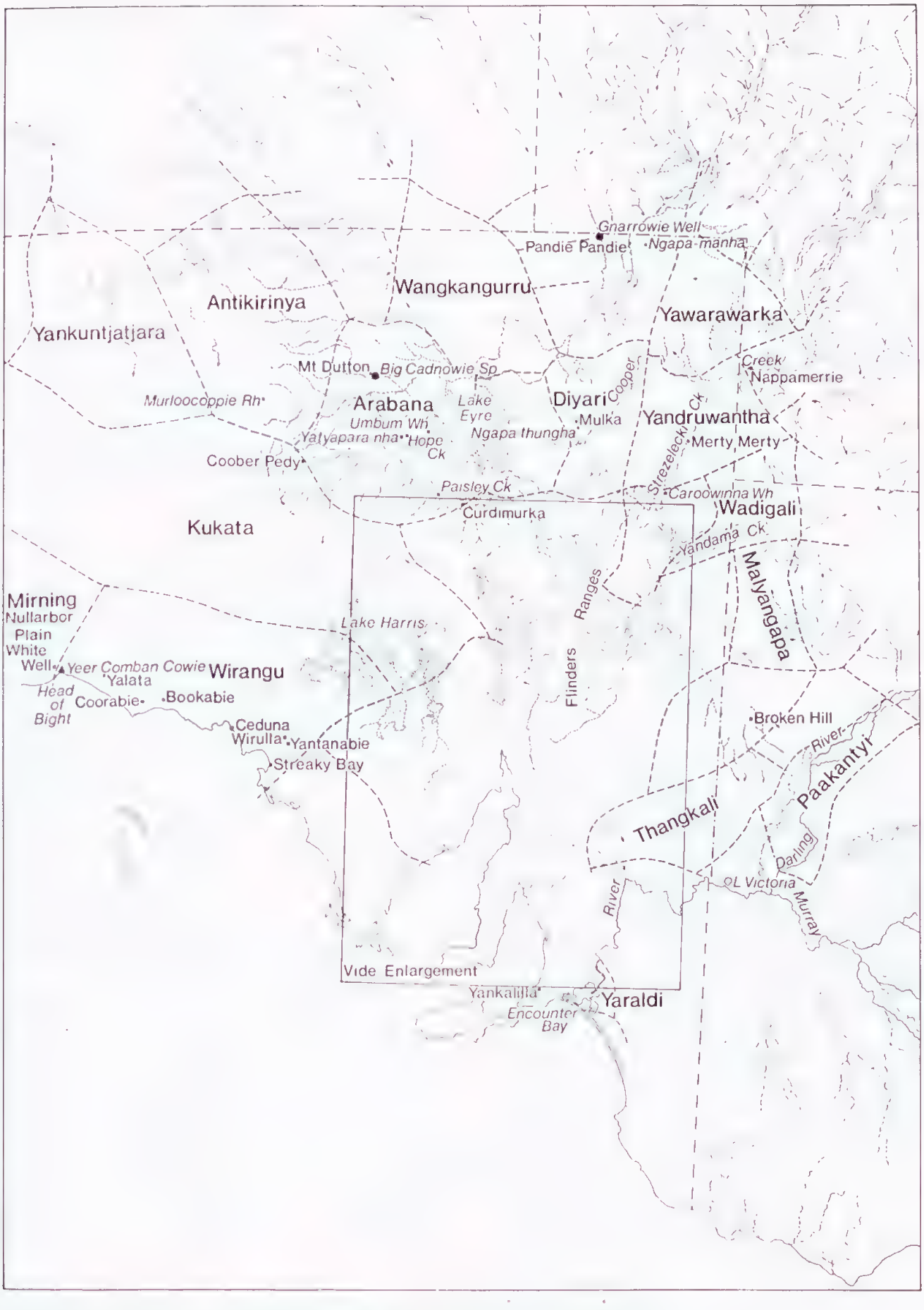

FIGURE 1. Distribution of Aboriginal language groups in southern South Australia.

Waterlowie Bore	*Wartul(i) awi* 'Ringnecked parrot Water'; near the north-eastern edge of the Flinders Ranges.
Wepowie Mine	*Wip'awi* 'Ant Water'; north-east of Parachilna
Boudowie Well	derivation unknown; near Burr Well.

Tunbridge (1988: 92 ff.) relates the myth of the 'Two Mates', the Cross-Cousins *Wartalyunha* and *Yanggunha* 'the Left-handed one' who created some of the springs and waterholes in the eastern Flinders Ranges. This myth, among others, gives the background to a few of the *-awi* names:

Ungoonya Spring	*Yanggunh 'awi* 'the Ancestor[5] *Yanggunha* Water' (Tunbridge 1988: 171).
Wertaloona Spring	*Wartalyunh'awi*, 'the Ancestor *Wartalyunha* Water' (Tunbridge 1988: 169,171).
Nepoui Spring	*Nhip'-awi* 'Flat rock Water'.
Arcaroola Springs	*Akurr-ul'-awi* 'the Arkaroo-serpent-stretched-out Water'.
Wattle spring	*MatyrarraRinh'awi* 'Filmy Water'; near Mt Chambers.

There are some names in Adnyamathanha that always contain *-awi*, but this final is sometimes omitted in names on maps, such as *Pinth'awi* Pinda Springs, 'Pay-back Water'; west of Mulga View in the Northern Flinders Ranges. Because Adnyamathanha vocabulary is well recorded and there are still speakers, it is possible to interpret most of the names. The difficulty of interpreting names, if there is no traditional information , and if they are known only through English spellings, is shown by the following:

Moorowie	*MuR-awi*, well near Mt Chamber, 'Thirst-water', in Adnyamathanha country.
Big Moro Gorge	*Mur'awi*, 'Ancestor water' from the word *mura* 'Ancestor'. *mura* in Adnyamathanha is also the name of a small goshawk, but traditional information, recorded by John McEntee shows that the derivation was from *mura* 'Ancestor' (J. McEntee, pers.com.).

We know only through the evidence of Adnyamathanha speakers that there are totally different derivations for Moorowie and Big Moro Gorge. The two names are unconnected, they are associated with two words that are distinguished from each other by having a retroflex -R- and a front tapped -r- respectively.

There is a third place with a similar name, 'Moorowie', a dam south of Manna Hill, in Ngadyuri country. As there are no Ngadyuri speakers, we do not know whether it was once *mura* or *muRa*. Moreover, in the absence of traditional information, we do not know whether, if it was *mura*, it meant 'Ancestor' or 'goshawk'. There is an entry for 'mura', 'goshawk' in the Ngadyuri vocabulary by Berndt and Vogelsang (1941), but this does not prove anything for the place-name.

In Parnkalla country

There are a few of the typical -owie names in Parnkalla country. It is not possible to interpret them with any certainty whatsoever, but attempts can be made thanks to the brilliant work of Schürmann 1844 and with the help of comparative data:

Marachowie Spring	'Marrity'awi', (from 'marritye', 'cat'), 'Cat Water'; near Yadlamalka, north-north-east of Port Augusta.
Belcherowie Well	'Paltyarr'awi', 'Rat Water' (from 'paltyarra', 'rat'); near the Moralana Creek and close to the eastern edge of Lake Torrens.
Yeltacowie Creek, and Lake	'Yalta-kawi', 'Crack (in rocks) Water', parallel in meaning to the Adnyamathanha place-name 'Italowie'; near the northernmost edge of Pernatty Lagoon.
Manucowie Wells	'Manu-kawi', 'Back Water'; south-east of Bookaloo. Both this name

[5] Tunbridge uses the term 'heroes' to refer to mythological Ancestors.

and the preceding are unusual in that they show preservation of the initial k-sound of *(k)awi* 'water'.

Etowie Creek. 'Irt'awi', 'Bird Water'; near the eastern side of Lake Torrens; south of Moralana Creek.

Nonowie this could perhaps be 'Nanna+awi', 'Bad Water'; near Whyalla.

Billabowie meaning unknown, near Kyancutta.

Some *-abi* names too can be found on upper Eyre Peninsula, such as Currabie near Mt Wedge and Carappee south-west of Kimba, both of which probably represent 'Kar'abi' 'Grassy plain Water', and Moonabie (possibly 'Munna-abi', 'Chest Water'), south-west of Whyalla. These -abi names are based on 'kapi' which is quoted by Schürmann as an alternative word for 'water' in Parnkalla.

In Nauo country

There are some interesting placenames of this kind in the far south of Eyre Peninsula which would indicate that Nauo shared in this development, using only -awi. The names in -abi do not appear on western Eyre Peninsula till just south of the latitude of Venus Bay in Wirangu country, with Chintabie, Courtabie, Warrapie, Moyappie and Thulinippie. The more southerly and presumably Nauo names are:

Mungerowie between Port Lincoln and Coffin Bay.

Woolawae some 15 km north-east of Coffin Bay.

Titjowie Dam about 15 km south-east of Lake Giles Conservation Park.

Most interesting of all is:

Wepowie some 25 km north of Coffin Bay, 'Ant Water'. This is identical in formation to the Adnyamathanha Wepowie, *Wip'awi*, 'Ant Water'. north-east of Parachilna, and to Wepowie north-east of Booleroo Centre in Nukunu country (see below), and also to Weebubbie, probably *Wiba'bi* 'Ant Water' near Eucla.

In Nukunu country

There is only limited information available on the Nukunu language, mainly from Gilbert Bramfield (Hercus 1992). Even with the use of comparative data it is not possible to analyse most of the place-names. The following are some examples:

Warcowie is now pronounced *Wark'awinha* by Adnyamathanha people (McEntee & McKenzie 1992), but as it is by the Warracoo Creek it is likely to have been based on a Nukunu form *waraku + awi* 'Long Water'.

Winninowie Creek possibly based on the Nukunu equivalent of Parnkalla 'winninya', 'dry grass' hence 'Winniny'awi', 'Dry grass Water'; between Port Augusta and Nectarbrook.

Ulalowie Hut derivation unknown, west of Kanyaka.

Capowie Creek possibly 'Kap'awi', 'Marrow Water'; near Quorn.

Willowie there is a remote possibility that this is connected with a Nukunu equivalent of Adnyamathanha *wirlla* 'lizard'; near Melrose.

Wepowie 'Wip'awi', 'Ant Water'; north-east of Booleroo Centre.

Tarcowie derivation unknown; south-east of Booleroo Centre.

Telowie Creek 'Thilh'awi', 'Thorny Saltbush water'; between Port Pirie and Port Germein.

Tandowie this name is probably 'Thand'awi', 'filled up (waterbag)', (J. McEntee, pers.com.), from 'thandu', parallel to the Ngadyuri *Yand'awi* , from *yandu* 'filled up'; listed below. In Nukunu lenition of initial consonants does not occur, hence an initial *th* does not change to *y*; south of Wirrabara.

Milcowie Dam derivation unknown; north of Crystal Brook.

Not found on maps, but recalled by Gilbert Bramfield:

Kariyawi 'Emu Water', spring south-west of Mt Remarkable. This

name is exceptional in that the final *-i* of *kari* 'emu' is not elided.

Pinthawi spring behind Port Germein, probably 'Pay-back Water' like Pinda Springs in Adnyamathanha country.

The following places were probably in Ngadyuri rather than Nukunu country:

Yandowie Mine probably '*Yand'awi*' from *yandu*; 'loaded up, filled', referring to a waterbag. The name is associated with a myth (Tunbridge 1988:54) in which during a drought an Ancestor comes from Curnamona chasing a kangaroo, and from its skin he ultimately makes a waterbag (J. McEntee, pers.com.); west of Baratta.

Bucketowie Hill possibly 'Pakart'-awi', 'Sore Water', north-east of Craddock

Wongowie Bore derivation unknown; close to Bucketowie Hill.

These are the most north-eastern of the *-awi* names in the Southern Flinders: further north-east is Yardliyawara country, where place-names ending with the word for 'water' are not found.[6]

In Ngadyuri country

Information on the Ngadyuri language is limited, confined mainly to a comparative word-list with Diyari, published by Berndt and Vogelsang (1941). The *-awi* place-names are very common in Ngadyuri country. Examples are:

Wilcowie 'Wilk'awi', 'Dog Water'; north of Belton.

Buckalowie Creek, Hill, and Bagalowie Bore 'Pakal'awi ', 'Frost Water'; north-east of Belton.

Canowie 'Kany'awi', 'Stone Water'; south-east of Jamestown. The Ngadyuri word for 'stone (in a creek')' is written as 'gunja' by Berndt and Vogelsang 1941. This name is exactly parallel to *Kadnyawi* quoted below.

Yardlowie Well and Hill This name could possibly be connected with the Adnyamathanha word *yardla,* 'pointed hill'; near Manna Hill.

Caltowie 'Kalt'awi', 'Sleepy Lizard Water'; west of Jamestown.

Dillowie Creek probably the same as Telowie in Nukunu country, 'Thilh'awi', 'Thorny Saltbush Water'; south-east of Jamestown.

Booborowie derivation unknown; north-west of Burra.

Bimbowrie Creek and Hill 'Pinp'awi', 'Murray pine Water'; north-north-west of Olary. This was probably at the border of Wilyakali country.

Wilyakali belongs to Paakantyi, the Darling River language group, and like the other Darling River languages it does not have place-names of the 'Finch-water' type. There are therefore, apart from the exceptions discussed below, no more names in *-awi* further to the east, nor any formed with the Paakantyi equivalent which was *nguku.*

In Narangga country

Narangga country basically comprised Yorke Peninsula as far north as about Port Broughton, where it adjoined Nukunu country. The most important information on Narangga, and particularly southern Narangga country, comes from Louisa Eggington who talked to T. Howard Johnson between 1898 and 1900 (published 1930–1931). Fortunately she also spoke many years later with Tindale. His work (1936) contains a vocabulary and summaries of some myths. Many of the place-names, particularly names of waterholes, end in *-awi.* There was a variant form 'kapi' for 'water' in Narangga (Tindale 1936: 61), just as there was in Parnkalla. This was attested earlier by Sutton (1887–1888) who writes 'cabbie', 'water'. Some of the most interesting examples of place-names given by Tindale are the following:

Hilderowie Well 'Ilar'awi', 'Dwarf Water', from mythical beings called

[6] Interestingly enough the word *ngapa* 'water' does occur in final position, not in a place-name but in the name of a group, the *Malya-ngapa* 'Salt-lake water' people of far western NSW, who were closely linked to the Yardliyawara.

'ilara' who once dwelt there. Their camps are said to be still there as mounds; near Marion Bay.

Coobowie — 'Kup'awi', 'Ghost Water'; just north of Edithburgh; for 'kupa' 'white' see below under Murloocoppie.

Pondalowie — 'Pantal'awi', 'Limestone Water', (probably 'parntal'awi', cf Adnyamathanha *varnda* 'limestone', the *-l-* being probably explicable as an epenthetic consonant); near the south-western tip of Yorke Peninsula.

Woorowie, Big Scrub Hut — 'Wurawi', derivation unknown.

Goonderowie, Dust Holes — 'Kundar'awi', 'Bad Water', according to Tindale probably connected with *kudna* 'excrement', a word still recently recalled by Narangga people; south of Daly Head.

It appears that in Narangga, as in Wirangu, the *-a-* of *-awi / -abi* was elided, rather than the final vowel of the preceding word. There are no examples of *-awi / -abi* with words ending in *-u*, but this feature can be seen clearly with two words ending in *-i:*

Calloway — 'Kali'wi', 'Dog Water'; near Daly Head.

Carriebie — 'Kari'bi', 'Emu Water', near Black Hill Conservation Park.

Sometimes, however, the word for 'water' remained unchanged, maintaining its initial *k* , as in:

Orrie-cowie — 'Nguri-kawi', interpretation suggested by Tindale, but meaning unknown; west of Warooka.

Bubla-cowie, Bubladdowie — written as 'Bablikawi' and 'Babladawi' by Tindale, with the interpretation 'where young men are circumcised'. Presumably the term is cognate with Kaurna 'pappa', 'young initiate'; west of Weaver.

Wirangu

The Thura-Yura word kawi 'water' existed also in the Wirangu language of the West Coast. It is attested in the earliest known vocabulary there is, that of Eyre. He writes (1845):

kau-we, gaip-py—water.

The term 'kawi' is found in the name of the important Ilcumban well near the Head of Bight, 'Yeer Comban Cowie', recorded by Eyre (1845: 240). The spelling 'gaip-py' no doubt represents gabi/kapi. This was either a very early borrowing from Kukata, or it existed all the time in Wirangu. Parnkalla similarly had two forms, both attested by Schürmann (1844) and the same situation existed in Narangga (see above). The names of many other rockholes in Wirangu country end in *-abi*. The rules for attaching *-abi* are as in Narangga, with loss of the initial -a- of *-abi:*

Examples are:

Bookabie	*Buga'bi*	'Stinking Water'.
Coorabie	*Gura'bi*	'Magpie Water'.
Cundilippy	*Gurndili'bi*	'Auntie Water'.
Hasting's place	*Mumbulu'bi.*	
Korgabie	*Gurga'bi.*	
Possum rockhole	*Birlda'bi*	'Possum Water'.
Walpuppy Well	*Walba'bi,*	'Hill Water'.
Puntabie	*Barnda'bi*	'Rock Water'.

Other examples, with meanings that are not certain are:

Yantanabie — on the highway, south-east of Wirrulla.

Alcannabie — just south of Streaky Bay.

Gilgarabbie Bore — south-west of Nullarbor Plain.

Waltanabie Tank — near Yalata.

Nalanippie — south of Nundroo.

Waltabie Well — *'Waltha'bi'* (var. *Waltya'bi)* 'Eaglehawk Water'.

Wiltabbie Well — *Wilth'abi* (probably var. of *Wilty'abi*) 'Old Water', near Wilgena.

There are various other spellings for the same final, notably ' -bee' and '-ppy:

Walenippi tank — north-east of Smoky Bay.

Jumpuppy Dam — close to Walpuppy, south-west of Lake Gairdner.

Arcoordaby Rockhole and Well — west of Lake Harris.

Peelanibbee Water — north of Head of Bight.

The easternmost of these names is Mintabie Well, west of Lake Hart, *Minta'bi* 'Round Water,

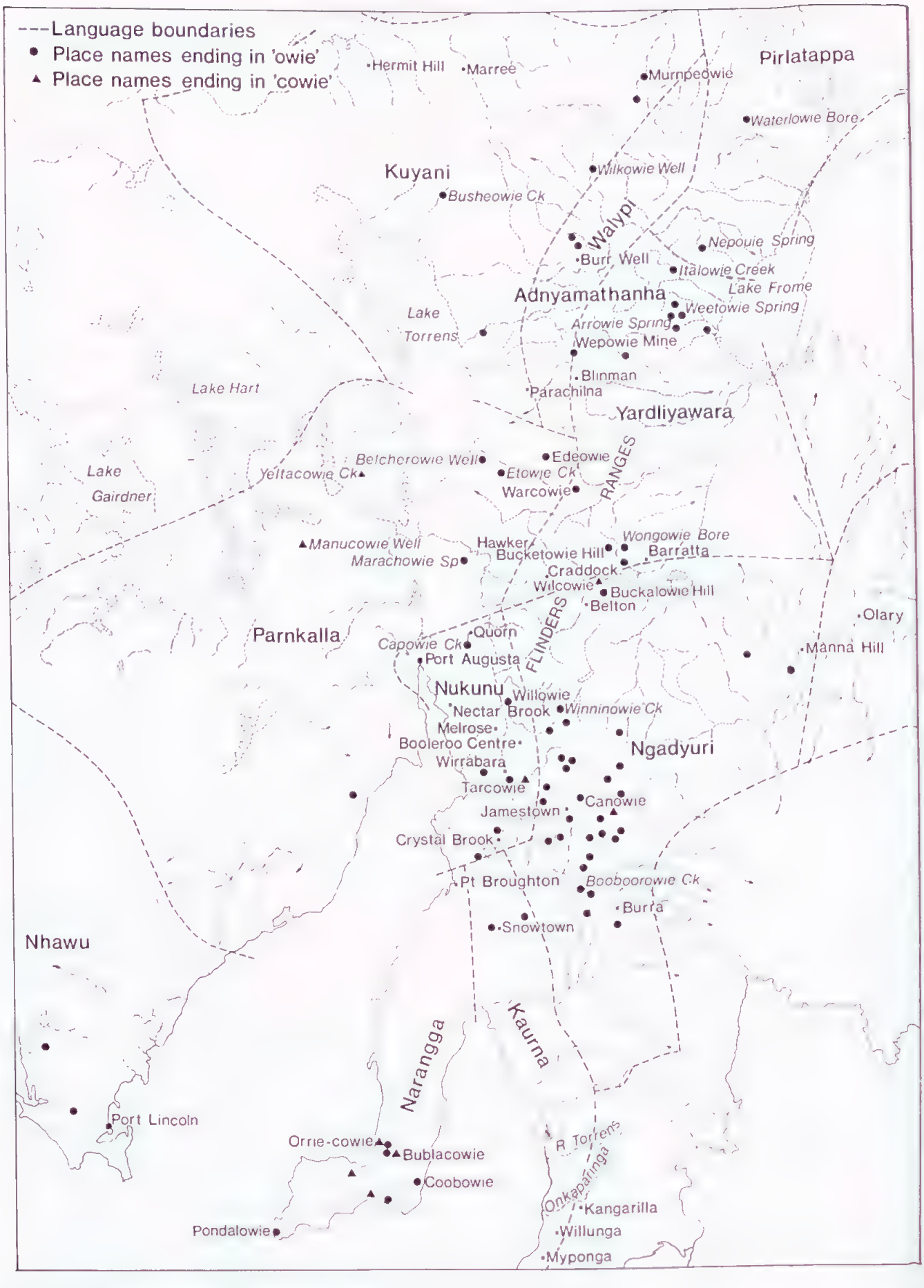

FIGURE 2. Distribution of '-awi' place-names.

lit. 'Navel Water'. This is distinctly a Wirangu name, as Parnkalla has assimilation of 'nt' to 'nn', and therefore *minta* is represented by 'minna' in Parnkalla.

There are a number of names in *-(a)bi* in the area along the coast between White Well and Eucla on the Western Australian border, an area which had no permanent water and was probably only sporadically used as a hunting resource by Wirangu people from the east and Mirniny people from the west. This becomes clear from a study of historical sources, particularly Daisy Bates, carried out by Tom Gara (Gara & Cane, MS.). People also came to the great quarry near Wilson's Bluff and for ceremonies in the area.

Mallabie Tank	possibly *Malya'bi* 'Mud Water'; to the west of White Well.
Cundalabbie	further west from Mallabie.
Yangoonabbie Tank and Bore	*Yangguna'bi*, 'Cockatoo Water'; half-way between the Head of Bight and Eucla.
Bunabbie Blowhole, Rockhole and Tank	probably *Barna'bi*, 'Goanna Water', close to Eucla.
Weebubbie	probably *Wiba'bi* 'Ant Water' near Eucla. This cave with a spectacular underground pool appears to be the westernmost of this continuous series of names.

These are all Wirangu names, not Mirniny: *yangguna* is the Wirangu word for 'cockatoo'. In Mirniny the word for 'water' was 'midyal', and it does not appear to have been used as a common feature of geographical names, neither were *midhal* and *kabi* in the neighbouring and closely related Ngadyumaya language (von Brandenstein, 1991: 160–163). The Eucla area thus represents the westernmost extent of the bulk of the *-awi* and *-(a)bi* place-names, though there are a few isolated names in *-(a)bi* further west. Daisy Bates's manuscript gives place-names between Eucla and 'Madhuru' (Madura), and there are just three of these names, all referring to 'waterholes in gullies along cliff sides': Kallalabi near Eucla, 'Kalliabi' (this is clearly another 'Emu Water') and 'Jillong Gabi'. These may well have been formed under the influence of the Wirangu method of naming.

Far-Flung Place-Names

Of the numerous Australian place-names ending in -owie there are isolated examples in areas far distant from Thura-Yura country, and in these cases it is usually quite obvious that they have nothing to do with the Thura-Yura word for 'water'. Typical of such place-names is Nowie in Victoria and associated sites nearby such as the Nowie channel. The derivation of this place-name is known: it comes from the word *Nyawi* 'Sun' in Wembawemba and related Kulin (Victorian) languages. The only conspicuous set of place-names is from Gumbayngir country, on the edge of the New England tablelands. These belong to presumably a quite different derivation. The references are:

Willowie Creek stream	29 17 152 22 SH5606 9339 NSW.
Coolowie homestead	29 58 150 23 SH5605 8938 NSW.
Koukandowie Creek	stream 29 54 152 51 SH5606 9438 NSW.
Koukandowie Mountain	mountain 29 59 152 52 SH5606 9438 NSW.

The Gazetteer shows that a few homesteads, from Western Australia to Tasmania, that have names in -owie, which may reflect the presence of homesick South Australians.[7] Here we discuss only those names that are clearly relevant: they look as if they could be Thura-Yura names, they refer to sources of water and they occur in areas not altogether outside the most remote reach of Thura-Yura people.

[7] As pointed out by R. Amery (pers.com.) other factors were at work too in spreading names for homesteads far afield. H. M. Cooper's work of 1949 *Australian Aboriginal Words and their Meanings* and later the even more popular work of A. H. and A. W. Reed *Aboriginal words in Australia*, and A. W. Reed *Aboriginal Place Names* played a part in this: 'people looked up these books and liked the sound and meaning of the words and didn't worry at all where they came from. Indeed publications like Cooper's make no indication whatsoever where the words originated from. 'Willowie' appears in the 1957 edition of Cooper and perhaps in earlier editions.' (Amery, pers.com.)

Kadnyawi

There are a few such Thura-Yura type place-names ending in *-awi* in areas surprisingly far from Thura-Yura country. The one best known to Aboriginal people – and geologists- is *Kadnyawi.* This is the Aboriginal name of two springs near Mt Dutton, south of Oodnadatta. There is a 'Big' and also a 'Little' Cadna-Owie Spring, but only the 'Little' one is marked on the modern map-sheets (27° 47', 135° 41' SG5315 SA). Arabana people also used the term for Mt Dutton itself, and it has also become the name for the special type of geological formation exemplified by Mt Dutton. There is no mystery about what the name *Kadnyawi* meant to the most senior Arabana people: it meant 'Rock Water', but its origin is perplexing. One thing is quite certain, it is not Arabana, though the location is in the heart of northern Arabana country. The Arabana word for 'rock, rocky hill' is *kadnha* and this is in fact the pronunciation that would be equivalent to the European spelling Cadna, but Aboriginal people have never been heard by us to pronounce the place-name that way, they always say *Kadnyawi.* Further south in Kuyani and Adnyamathanha country the word for 'rock' is *kadnya* and *adnya* respectively. The name can thus be analysed as: *kadnya* = rock, hill, (c.f. Kuyani, Parnkalla, Nukunu *kadnya.*) plus *awi* = water, c.f. Kuyani *kawi,* Adnyamathanha *awi,* (the Arabana word for 'water' is *kutha).*

The meaning is therefore 'Rock Water', i.e. a rocky hill with springs, which is most descriptive of Mt Dutton. There is an identically formed name, Canowie, in Ngadyuri country (see above).

Mick McLean, the last person who could sing the songs for Mt Dutton, was puzzled by the name, as were other older people recorded in the sixties: 'I don't know why that place has Adnyamathanha's name!' *Kadnyawi* is important in mythology, it is a centre for the myth of the Pounding Stone and it plays a part in the myth of *Karlantyi,* the Bicycle Lizard. Whether either of these myths had links to the south, now long forgotten, we do not know, and so the origin of this name remains a mystery. Younger Arabana people have sometimes re-analysed the name as *Kadni-awi,* 'Lizard Water'.

Gnarrowie Well

This is the northernmost South Australian name ending in '-owie': it is a waterhole and soakage well just 3 kilometres south of the Queensland border on a small far western channel of the 'Georgina', i.e. Eyre Creek. 26 02 138 51 SG5409 6645. It is on the eastern edge of the Simpson Desert, in the country of Karangura people, who became extinct at the beginning of this century (Hercus 1991). Wangkangurru people called the site *Ngurrawani-(nha)*[8]*:* (Mick McLean on Hercus Tape 66, 1966). It was important both mythologically and historically, being effectively 'the last water'. It figured in the long myth of The Two Boys and was the centre of an area known as *Kawuka,* a ritual centre for the increase of birds of all kinds. It seems likely that the name Gnarrowie is not connected with the word *-awi* 'water', but was simply a corruption of the original name *Ngurrawani-(nha).*

Napeowie Waterhole

This waterhole is on a northern channel in the floodplain of the Cooper, in Yawarawarrka country at 27° 44', 140° 30', about 25 km west of Innamincka. No information is available on this place, the name is not listed by Reuther. The first part of the name may represent *ngapa* which means 'water' in Yawarawarrka and neighbouring languages. The second part of the name looks exactly like the Adnyamathanha word for 'water', but it is possible that here too we have a corruption of an unknown older Yawarawarrka name. Many important myths and song-lines are known to have travelled along the Cooper. The Napeowie waterhole is close to the important Kadripariwilpa waterhole, but it is not known as being a ritual centre that would have attracted visitors from afar. The origin of the name is therefore unknown.

Strzelecki Waterholes

There are two waterholes along the Strzelecki Creek in Yandruwantha country near Merty Merty and further south which could possibly have names in ending in Thura-Yura *-awi:*

Cadrapowie Waterhole 28° 33', 140° 17' SH5402.

Narcoonowie Waterhole 28° 44', 140° 12' SH5402.

A bore which appears to have an identical name is Nargonowie Bore 28° 28', 140° 49' SH5402. These places are in the middle of Yandruwantha country and Cadrapowie is at least partly a Yandruwantha type place-name, seeing that it

[8] Wangkangurru place names optionally take the proper name marking suffix *-nha,* cf below, Conclusion (2).

contains the characteristic sound-sequence *dr* found in the Diyari language group. There are a number of Yandruwantha-Yawarawarrka place-names which begin with *kadri* 'creek'. Too little is known about Yandruwantha sites for any conclusion to be possible. The influence of Thura-Yura cannot be ruled out, since the waterholes along the Strzelecki Creek are known to have been on the ochre route to the great mine at Parachilna in the Flinders Ranges, near the border of Kuyani, Parnkalla and Adnyamathanha country.

The name of the Caroowinna waterhole on the Strzelecki close to an important site near Chidlee is probably not linked at all with names in *-awi*. Reuther (VII 604 & 616) quotes two Yandruwantha place-names 'Karuwini', of which this is probably one, and the other is probably Carraweena, also on Strzelecki Creek.

Marnpi-awi Murnpeowie 'Bronzewing Pigeon Water'

This is the name of the large station situated by a waterhole in the Tooncatchyin Creek. It is a little to the north of Adnyamathanha country, in what was Diyari country according to Tindale, where the word for 'water' was *ngapa*. The name of the waterhole seems to have been originally simply *Marnpi* 'Bronzewing Pigeon', and Aboriginal people who have worked there still refer to the station by this name. 'Manpi' is also the name given by Reuther (VII: 1042), who associated the place with the sighting of a flock of pigeons by the Ancestors 'Kalkuwulana', 'the Two who belong to the Reed matrilineal descent line' (cf Reuther I: 1278):

> The two muramuras Kalkuwulana ('two reeds'), together with their father, Kalukupana, are listed as a constellation. These three once caught some fish with a dundru [= net] (c.f. dander and the story of Kalukupana). They saw a flock of pigeons there.

The station was originally called 'Blanchewater', and the main homestead was by the Blanchewater Creek. The name Murnpeowie does however appear on the pastoral map in use before 1888, for the name of the waterhole, as 'Murnpeowie Water'. Despite this early date it is still likely that Adnyamathanha stockmen introduced the name long ago. Over recent years, on account of the name, people have associated it with the Adnyamathanha-Ngadyuri Bronzewing Pigeon story, and the story is now sometimes said to start at Murnpeowie. We have thus an instance of an Adnyamathanha name being introduced into another country, and the myth following the name, whereas in the case of *Kadnyawi* 'Mt Dutton' the name probably followed the myth.

Murnpeowie is not far removed from other Adnyamathanha type names; for example, Aganowie dam is only some 20 km to the south. This may well also represent an introduced name, and a kind of 'overflow' from nearby Adnyamathanha country. How easily a name can be introduced is shown by evidence from John McEntee of Erudina Station, who has studied the Adnyamathanha language for many years, particularly from the late John McKenzie. Regarding the name Wundowie John McEntee writes (pers.com.):

> John McKenzie once told me that whoever was putting the bore down and struck good water at that place, asked John, or one of his family who happened to be working in the area at the time, 'What would you say for 'good water' in the Aboriginal way?' The answer came back as *'warndu-awi'*, i.e. *warnd'awi*, hence Wundowie.

Murloocoppie *Marlu-kapi* 'Kangaroo-water'

This is the name of some rockholes on the Stuart Range to the east of the railway line and off the Highway from Pootnoura Siding. It is also the name of a rockhole and of a bore, both to the west of the line and highway. The site of the western rockhole and the site of the bore were first called *Marlu-kapi* on the 1910 pastoral map, which also named a 'Murloocoppie Pastoral Co'. The eastern rockholes however have only been named so recently; they do not have this name on older maps, nor did they have it traditionally. This is a Western Desert (Kukata, Yankunytjatjara) name of relatively modern origin, as the area was once Arabana country, and obviously the sites covered by the name have been expanded much further very recently indeed (only in the post-1987 Murloocoppie mapsheet SH53–2) by the inclusion of the eastern rockholes. Pootnoura *Pudnura* is an original Arabana name, with the typical pre-stopped consonant *dn:* it was part of the country of the *Midlaliri,* the no longer extant western branch of the Arabana people. The name 'Murloocoppie' is likely to have been brought into the area by Kukata people with connections to the south. It is probably similar in date and origin to 'Coober Pedy', some distance to the south; this contains the word *kupa* 'white man', based on Parnkalla and Narangga 'kupa', 'ghost', 'white' (see Coopowie in Narangga country). The word *marlu* 'kangaroo' is Kukata-Yankunytjatjara, but the compound 'Murloocoppie' represents the Thura-Yura type of place-name with the word for 'water' coming at the end.

The place name 'Mintabie', associated with an opal field near Marla Bore, belongs to an area that is traditionally Western Desert country. This name also appears to be brought in by Kukata people with links to the south, and is identical to the name of the site, mentioned above, on the eastern side of Wirangu country near Lake Hart. Kukata, like other Western Desert languages, originally did not have place-names ending in the word for 'water', but Kukata people to some extent adopted this system of naming. It seems that place-names of the *-abi* type were transported by Kukata people to an area far away from Thura-Yura country in relatively recent times.

One other interesting example, due to Kukata influence, is 'Burntiltapy' near Ingomar[9], south of Coober Pedy and on the edge of traditional Kukata country. This is a Thura-Yura-type name ending in *-(a)bi* 'water', but the first part of the name contains the Arabana word *pantilta* 'fighting with one another'.

-awi in Far Western NSW

Euriowie is a most important engraving site some sixty kilometres north-north-east of Broken Hill. George Dutton, of Bandyigali descent, was the greatest authority for this area, and was acknowledged as such by Tindale (1939). George Dutton told Luise Hercus in 1968 that the Seven Sisters camped all along this creek and were constantly 'dipping' for water, i.e. they scooped up water with their hands and thereby deepened the creek. He thus confirmed information given to Elkin (1949: 139):

> A very trustworthy man of mixed blood, aged about fifty-five, whom I met at Nappamerrie belonged to the Wilyakali tribe..... He said that Euriowie was in the country of the Tinyano[10] tribe and that there were many markings in a rocky place along the creek near Euriowie. The engravings which represented tracks of men, babies and animals and also outlines of animals were made by chipping with a narrow hand chisel. He added that the old natives had told him that the Seven Sisters had made the petroglyphs with chisels before going up to the sky to live.

There can be no question as to the importance of this site (see also McCarthy 1970: 18). McEntee (1991) has shown how people travelled for ceremonies from the Flinders Ranges to Wilyakali country, to Poolamacca, north of Broken Hill. Euriowie is only some fifteen kilometres from there. It is therefore highly likely that Adnyamathanha people took part in ceremonies at this site also, and may have given their own name to this site. The word *yuri* means 'ear' in both Adnyamathanha and all the Paakantyi, Darling River languages, including Wilyakali, but the suffixing of *-awi* is of distinctly Thura-Yura origin.

There are two other names in Paakantyi country that could possibly represent borrowings from Thura-Yura, but nothing is known about them. One is Lake Narowie some 70 kilometres east of Broken Hill, the other is much further south, Tarawi, north of Lake Victoria, recently made into a nature reserve.[11]

Absence of placenames ending in *-awi*: Kuyani

In Kuyani country, and Arabana-Wangkangurru country, as well as in the area where Diyari and closely related languages were spoken, place-names do not end with the word for 'water': place-names containing the word for 'water' are formed quite differently.

The prevailing order in descriptive phrases in Australian languages is:

noun + adjective.

Thus one commonly says the equivalent of 'child good' and 'ground hard'. This is reflected in descriptive place-names: thus there are numerous places in the Lake Eyre Basin that mean 'bad water' or 'stinking water', with the word for 'water' coming first . Examples are:

Ngapa-thungka	'Water stinking', the Appatoonganie waterhole, south of Mulka near the Birdsville Track (Diyari).
Ngaka-thungka	'Water stinking', Nockatunga in South West Queensland (Wangkumara).
Ngapa-manha	'Water bad', the Appamana waterhole South-east of Pandie Pandie off the Birdsville Track (Yawarawarrka).

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[9] Ingomar is an Arabana name: *Inka-mangu* 'Yam forehead', the bald knob of root material left in the ground when a yam has been freshly cut.

[10] This is a clan name referring to the people of the Tinyano Range. 'Tinyano' was the old name of the Range to the east of the Barrier Range: the north-easternmost section of it is the Byjerkerno Ridge, running north-north-west from Euriowie (c/f also Le May, MS).

[11] Information from Peter Thompson of Wilcannia.

Ngapa-kaldri 'Water bitter', Lake Ngapakaldi in the Thirrari Desert (Thirrari).

The meaning of these place-names is exactly the same as 'Bookabie' in Wirangu country, listed above. It is however quite different in formation from 'Bookabie', which is of the 'Finch-water' type, where the final part of the compound singles out some attribute of the place, and where *-awi/abi* in fact fulfils the function of a post-positional classifier.

The Arabana-Wangkangurru word for water, *kutha*, is a relatively recent borrowing from the Arandic languages to the north which have *kwatye* 'water' (Hercus 1987: 73–80). This word is therefore not reflected in place-names with one exception, which is probably of recent origin:

Kutha-Parkulu 'Waters-two', a double spring just north of the Neales, west of Algebuckina.

The original word for 'water' was *ngapa*, as in the Diyaric languages, hence we find:

Ngapa Murilya 'Water dried out', Umbum waterhole (Arabana); this explanation appears already in Reuther (VII 1454).

Ngapa-kalti 'Water bitter' is the name of a waterhole of uncertain location on the Kallakoopah (Wangkangurru).

Ngapampara the lower Neales.

There are over 40 place-names beginning with *ngapa* 'water' listed for the Lake Eyre Basin by Reuther (volume VII), written at the turn of the century, but published only in 1981. There do not appear to be any names that end with the word for 'water'.

The two types of name-formation with the word for 'water' being the first or second member of a compound name are however not absolutely exclusive of one another, and there are in fact just a few Adnyamathanha names beginning with *awi* 'water'. Owieandana north of Mt Serle is the only one that appears on most maps. The name represents *awi-antha-nha* 'Water-Algae'.

Kuyani fits into this pattern of the Lake Eyre languages. The Kuyani word for 'water' is *kawi*. Kuyani country immediately adjoins Adnyamathanha on the western side. Although there are numerous springs and waterholes in Kuyani country, there do not appear to be any with names that end in *-(k)awi*, except in a small area not far from Parnkalla and Adnyamathanha country where we find:

Busheowie Creek and Well *'Puthi-awi'*, 'Down-feather Water'; on the north-eastern side of Lake Torrens. It is noteworthy that the final -i of 'puthi' is not elided here.

Old Winnowie *'Wina-awi'*, 'Chalk-water'; just south of the Ediacara Fossil Reserve.

Over the large area of the rest of Kuyani country there are no *-awi* names shown on maps, and we have not found any despite extensive work on Kuyani sites.[12] Names follow the 'Finches' type, not 'Finch-water'. Thus some springs opposite Hermit Hill are called *Murla-Murlapara-nha* 'A lot of crested pigeons', the Wangianna Springs are *Wanggiya-nha* 'Coolamon', and a small spring near Curdimurka is called *Thitari*, 'Baby' because in the myth of *Kudnangampa* a birth camp was there. The Kuyani word *kawi* 'water' does however appear at the beginning of a place-name: *Kawilanha* was the original form of the name Callanna, west of Marree. Alice Oldfield, the last fluent speaker of Kuyani, was born there in about 1885. The absence of names ending in *-awi* is all the more striking because of the fact that the Kuyani language is very closely related to Adnyamathanha: the two forms of speech can in fact be termed dialects of one language. In the formation of these place-names Kuyani people followed the practice of their northern neighbours throughout the Lake Eyre Basin and beyond, while Adnyamathanha followed the special Thura-Yura system. There are further traditional reasons behind this. Kuyani mythology and therefore Kuyani country was definitely northward-looking. All the main myths through Kuyani country travel along one axis, and only those marked * (below) go on from or to Parnkalla or Nukunu country, so more southerly

[12] There is one exception, Willowie Bore, shown only on the 1:100 000 map sheet Irrapatana (Billa Kalina) as being about four kilometres south-west of Welcome Spring. This could be the exception that proves the rule, but it could also be an import by Europeans, as there is a site with an identical name in Nukunu country, and one even in north-eastern NSW (see above under 'far-flung places' and also footnote 10). Aboriginal people never mentioned it to us as a site, though they gave names for the other spring/bore sites in the area.

Thura Yura people were not involved:
a. from north to south:
The Two Snakes *Yurkunangku* and *Kurkari*, the Two Emu Men, the Dogs*
b. from north to south and back again:
The Two Men*, The Grinding Stone Men, Old Man *Thudnungkurla*, The *Urumbula**,
c. from south to north
The Kangaroo, Old Man *Thunpila* carrying the dead body.

There are no major stories and songs that go in an east-west direction, except for part of the Seven Sisters myth. The fact that the main stories and song-lines were along this northern axis probably had a major influence on the naming of sites, and the principles of naming altogether.

Absence of placenames ending in *-awi*: Kaurna

Just as Kuyani was almost but not quite mutually comprehensible with Adnyamathanha, Kaurna was very close to Narangga. The situation appears to have been exactly parallel. Ibaritja, also known as Ivaritji, was the last fluent Kaurna speaker. Louisa Eggington, the Narangga speaker, told Tindale (1936: 55–6):

> that she had known Ibaritja and recognised that the dialects had much in common; nevertheless, she thought that Ibaritja 'was hard to understand'.

While, as shown above, Narangga had many place-names ending in *-awi,* there is no sure attestation of any such names in Kaurna country.[13] According to the maps, names in *-awi* peter out with the Condowie Springs north-east of Snowtown, and the Booborowie Creek north-west of Burra. The Kaurna people of the plains to the south and south-east of there simply do not seem to have used names ending with *-awi.* There is no dramatic difference between the Condowie Plain and plains further south, yet Kaurna people do not appear to have taken on the habit of forming these particular place-names. The system of using a descriptive or classificatory final is however not entirely absent: there are a number of rivers and creeks in the Adelaide Plains that are formed with the word 'parri', 'creek' as second member. Such names are not absent elsewhere in the area of the Thura-Yura languages, the best known being Wirrabara *Wira-paRi*, 'Gum Tree Creek' in Nukunu country.[14] They are however very prominent in Kaurna. Examples are (courtesy of Jane Simpson, pers.com.):

'Karrawirraparri'	'the River Torrens', (Teichelmann & Schürmann 1840).
'Moorta perringga'	'Upper vale of the Hindmarsh', (Wyatt 1879).
'Warriparri'	'the Sturt River', (Teichelmann & Schürmann 1840).

The most distinctive feature of Kaurna place-names is the use of the locative markers
'-ngga' (with disyllabic words) and '-illa' (with polysyllabic words) 'at such and such a place' as an integral part of a place-name, hence names like:

Onkaparinga *(Ngangki-parri-ngga)* Women-Creek LOC

and similarly Myponga, Willunga, Yankalilla, Kangarilla.

This system of having the locative as an integral part of a place-name is not used in the other Thura-Yura languages, however closely related, even Narangga. It is probable that it was a feature from further to the east, from the Encounter Bay language. Meyer (1840: 13) noted the use of locative case forms as place-names in this language:

> These words, Poltong, Kotungald, Wittingenggul, signify at the place which they designate.[15] What one would suppose from analogy to be the simple nominatives appear not to be used.

The clearest example of the correspondence between Kaurna and the Narrinyeri language of

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[13] There are a couple of -owie names of very recent origin in Kaurna country. R. Amery points out that the suburbs of Paralowie, according to Manning (1990: 161), was proclaimed on 27 Nov. 1980. It is stated there that the name is derived from two Aboriginal words para 'river' and 'owie', 'water'. It is highly likely that Europeans constructed the name. Amery also points out that the name of the 'Moorowie' walking track in Belair National Park was added along with other out-of-area Aboriginal names sometime between 1953 and 1968.

[14] Some names of creeks formed with -vari in the geographical index in Tunbridge 1988: 161 ff. may be due to the influence of the English pattern of adding 'creek' to differentiate the creek from a waterhole or other geographical feature of the same name. They were probably not always considered an integral part of the name. Only the simple names appear on maps, but this may be because there 'Creek' is being added anyway.

[15] Other well-known Narrinyeri place-name sending with the locative suffix are Coorong, Milang and Narrung.

Encounter Bay comes from Jane Simpson (pers. com.), and concerns the name of Encounter Bay itself:

> 'Encounter Bay' is called 'Ramung' by the Narrinyeri, and 'Wirramulla' (a variant of the name) by the Kaurna. They are two forms of the same name: '-ng' and '-illa' being the respective locative suffixes in the two languages, and 'R' being impossible word-initially in Kaurna.

Conclusion

The distribution of place-names formed with *-awi* presents a complex web of linguistic diffusion. The situation in summary is as follows:

1. Place-names ending in *-awi* or *-abi* are found throughout the area of the Thura-Yura languages including Wirangu, except for Kuyani in the north-west and Kaurna in the east.
2. The optional proper noun suffix *-nha* is characteristic of languages further north and in Thura-Yura it is found only in Kuyani and Adnyamathanha.
3. Kaurna forms a number of place-names ending with 'parri', 'creek' and among the Thura-Yura languages only Kaurna has the frequent use of the locative in place-names.
4. There are place-names in *-awi, -abi* beyond the limits of the Thura-Yura languages and some of these can be explained by traditional and ritual links.

It is possible that this distribution could have come about in the following way:

The process of using *-awi* as a descriptive or classifying term at the end of place-names as in *Idhi-awi* 'Finch-water' probably began long ago in Adnyamathanha and Ngadyuri country. It spread from there to Narangga, Nukunu, Parnkalla and Wirangu country. Kuyani people, who kept the northern way of simply saying 'Finches' instead of 'Finch-water', did not adopt it. Kaurna people did adopt the general principle of using a descriptive term at the end, as is shown by the names ending in 'parri'. Here they also developed their own way of naming by following the traditions of the neighbouring Encounter Bay language, using a location marking suffix '-ngga' and '-illa' at the end.

An alternative possibility is that all the Thura-Yura languages initially shared the 'Finch-water' type of place-names relating to water, and that Kuyani and Kaurna lost this method under the influence of neighbouring cultures. Whichever explanation one adopts, the situation with place-names shows that linguistic diffusion can overcome the strongest genetic links.

There are three main diffusionary processes at work:

1. Adnyamathanha and Kuyani both succumbed to influences from the north, adopting the optional *-nha* suffix which belongs to the Karnic languages (and is found as *-nya* in the Western Desert as well).
2. Kuyani either remained outside the sphere of diffusion of the *-awi/-abi* placenames, or lost them, under the influence of Arabana and other northern languages.
3. Kaurna either remained outside the sphere of diffusion of the *-awi/-abi* placenames, or lost them, under the influence of eastern neighbouring languages of the Yaraldi type.

Forms of speech that could be called dialects of one language and are almost mutually comprehensible, such as Narangga and Kaurna on the one hand, and Kuyani and Adnyamathanha on the other, thus came to differ from each other with regard to this salient marker of language-land affiliation. This shows up the well-known fact that Aboriginal languages are not predictable, one can never be categorical in making assumptions from one language to the next, however closely related. Cultural influences and the constant movement and interaction of people led to this complex diversity, which is clearly reflected in place-names. Each language is special and important and adds to the understanding of the whole diversity of the peopling of Australia.

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References

BATES, D. M. MS. Native Vocabulary compiled by Minbunga and Minjia (Lucy) of Yuriya. Daisy Bates Collection, Barr Smith Library, University of Adelaide: Adelaide.

BERNDT, R. M. & VOGELSANG, T. 1941. Comparative Vocabularies of the Ngadjuri and Dieri Tribes, South Australia. *Transactions of the Royal Society of South Australia* **65**(1): 3–10.

COOPER, H. M. 1949. 'Australian Aboriginal Words and Their Meanings.' South Australian Museum: Adelaide.

ELKIN, A. P. 1949. The Origin and interpretation of petroglyphs in south-east Australia. *Oceania*.**20**(2): 119–157.

GARA, T. & CANE, S. 1988 MS. Environmental, Anthropological and Archaeological Background to the Nullarbor Plains.

HERCUS, L. A. 1987. Using other people's words: a note on some compound nouns in Arabana, Northern South Australia. Pp.73–80. In T. L. Burton & J. Burton (eds.) 'Lexicographical and linguistic studies: essays in honour of G. W. Turner.' Cambridge.

HERCUS, L. A. 1991. 'Glimpses of the Karangura'. *Records of the South Australian Museum.* **25**(2): 139–159.

HERCUS, L. A. 1992. 'A Nukunu Dictionary.' The author, Canberra.

HERCUS, L. A. MS. Wirangu Grammar and Dictionary.

JOHNSON, J. H. 1930–31. The native Tongue, a valuable vocabulary. Published in the weekly southern Yorke Peninsula newspaper, *The Pioneer*, Yorktown. Friday December 26, 1930; Friday January 9th & Friday January 16, 1931.

Le MAY, P. MS. Introduction in 'Barrier Ranges Gold'. James F. Crawford's report on his Barrier Ranges gold expedition of 1859. In preparation.

McCARTHY, F. D. (ed.) 1970. 'Aboriginal Antiquities in Australia: Their Nature and Preservation.' Australian Institute of Aboriginal Studies: Canberra.

McCARTHY, F. D. 1970. Aboriginal Antiquities in New South Wales. Pp.15–26. In F. D. McCarthy (ed.) 'Aboriginal Antiquities in Australia: Their Nature and Preservation.' Australian Institute of Aboriginal Studies, Canberra.

McENTEE, J. 1991. Lake Frome (South Australia) Aboriginal Trails. *Transactions of the Royal Society of South Australia.* **115**(4): 199–205.

MEYER, H. A. E. 1840. 'Vocabulary of the language spoken by the Aborigines of South Australia.' Allen: Adelaide.

McENTEE, J. & McKENZIE, P. 1992. 'Adna-mat-na English Dictionary.' Published by the authors, Adelaide.

MANNING, G. H. 1990. 'Manning's Place Names of South Australia.' The author: Adelaide.

REUTHER, J. G. 1981. 'The Diari.' Translated by P. Scherer. AIAS microfiche no.2. Australian Institute of Aboriginal Studies: Canberra.

REED, A. H. & A. W. 1965. 'Aboriginal Words of Australia.' Reed: Sydney.

REED, A. W. 1967. 'Aboriginal Place Names and Their Meanings.' Reed: Sydney.

SCHÜRMANN, C. W. 1844. 'A Vocabulary of the Parnkalla Language, Spoken by the Natives Inhabiting the Western Shores of Spencer's Gulf.' Dehane: Adelaide.

SUTTON, T. M. 1887–88. The Adjahdurah tribe of Aborigines on Yorke's Peninsula: some of their early customs and traditions. *Royal Geographical Society of Australia (South Australian Branch) Third Session.* Pp.17–19.

TEICHELMANN, C. G. & SCHÜRMANN, C. W. 1840. 'Outlines of a Grammar, Vocabulary, and Phraseology, of the Aboriginal Language of South Australia, Spoken by the Natives in and for Some Distance Around Adelaide.' Published by the authors: at the Native Location, Adelaide.

TINDALE, N. B. 1936. Notes on the natives of the southern portion of Yorke Peninsula, South Australia. *Transactions of the Royal Society of South Australia.* **60**: 55–70.

TINDALE, N. B. 1974. 'Aboriginal Tribes of Australia: Their Terrain, Environmental Controls, Distribution, Limits and Proper Names.' Australian National University Press: Canberra.

TINDALE, N. B. 1939. Harvard-Adelaide University Anthropological Expedition Journal. Anthropology Archives, South Australian Museum.

TUNBRIDGE, D. 1988. 'Flinders Ranges Dreaming.' Australian Institute of Aboriginal Studies: Canberra.

von BRANDENSTEIN, C. G. 1980. 'Ngadjumaja: an Aboriginal Language of South-east Western Australia.' Innsbrucker Beiträge zur Kulturwissenschaft. Sonderheft 48: Innsbruck.

WYATT, W. 1879. Vocabulary of the Adelaide and Encounter Bay tribes, with a few words of that of Rapid Bay. Pp.169–182. In J. D. Woods (ed.) 'The Native Tribes of South Australia.' E. S. Wiggs & Son: Adelaide.

THE A. P. H. FREUND COLLECTION OF NEW GUINEA ARTEFACTS: AN HISTORICAL PERSPECTIVE

PHILIP FITZPATRICK

FITZPATRICK, P. 1999. The A. P. H. Freund Collection of New Guinea Artefacts held by the South Australian Museum. *Records of the South Australian Museum* **31**(2): 181–214.

A. P. H. Freund was one of a number of missionaries from Papua New Guinea who donated collections of artefacts and photographs to the South Australian Museum. Freund's main collections came from the Wabag Valley and the Menyamya area of the New Guinea Highlands between 1948 and 1953. This paper describes the historical context in which the collection was made and its relationship to similar collections held by the South Australian Museum and other museums in Australia and overseas.

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Introduction

The South Australian Museum has a number of significant Papua New Guinea collections made in the period immediately following the Second World War. During this period Norman B. Tindale, the Museum's Senior Ethnologist, enjoyed the strong support of the Museum Director, Herbert Hale, and was able to ensure that the collections coming into the Museum largely reflected his own research interests. It is useful, therefore, to understand Tindale's interest in Papua New Guinea before embarking on any detailed discussion of the Freund collection.

Tindale had briefly visited New Guinea in 1907 when the ship on which he was travelling with his parents to Japan called at Madang. In 1943 he had the opportunity to revisit New Guinea under very different circumstances. He had joined the RAAF in 1942 and, because of his background in Japan and his command of the language, had been assigned to the Pentagon to assist in the breaking of codes and the monitoring of Japanese military production. For this purpose a laboratory had been established in Brisbane to analyse debris from crashed Japanese aircraft (Jones 1994:162).

A number of aircraft had been shot down on the approach to the airstrip at Tsili Tsili on the Lower Watut west of Lae in August 1943, and were of interest to Tindale because they appeared to be new models. One was a 'Lily Mark 2', a new aircraft altogether. Anxious to examine it closely, Tindale left the RAAF base at Ardenfield at 4 a.m. on 22 Sunday August en route to Wards Strip near Port Moresby, arriving in the early afternoon. He flew on to Tsili Tsili the next day. Four crashed aircraft had been located, including one which had landed on a church in the engineer's camp killing the chaplain.

Tsili Tsili village had been deserted by its occupants but Tindale walked to a place called Pesen to inspect one plane and came into contact with the local people. He saw a number of interesting clay pots there and took notes. He also walked to another crashed plane near Morum village, just north of Tsili Tsili, and took photographs of the village and a 'red-skinned native boy called Fiugo who is a native of Tuyantuyu'. In the evening Tindale attended a sing-sing in another nearby village (Tindale 1943: 2).

Included in the journal which Tindale wrote at the time are photographs of Fiugo and Pesen village and a card with a reference to Beatrice Blackwood's 1939 article 'Life of the Upper Watut, New Guinea'. A reprint of this article is held in the South Australian Museum Library – presumably acquired by Tindale.

Tindale maintained his interest in New Guinea when he resumed his position as the Museum's ethnologist after the war. During 1948–49 he reinstalled and renovated the Museum's Pacific Islands Gallery, which had been removed to storage in a disused railway tunnel following the Japanese attack on Pearl Harbour in December 1941. Tindale had begun compiling a journal of notes and clippings related to the Pacific region as

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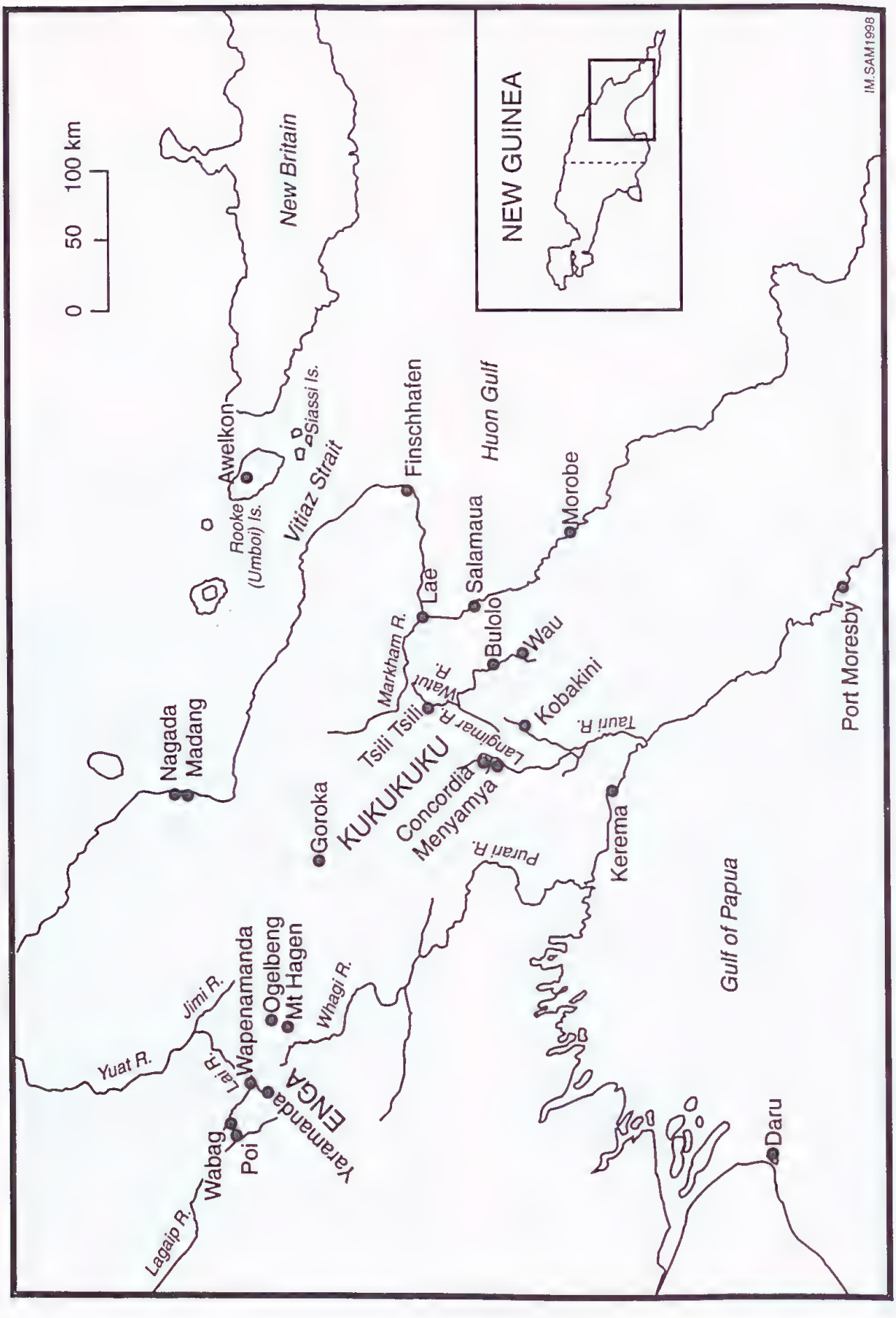
Pastor Freund died in Adelaide, 3 October 1998, aged 91 years.



Map 1. Areas in New Guinea where Freund worked.

early as 1934 when the spectacular discoveries of hitherto unknown large populations in the Central Highlands of New Guinea occurred (Tindale 1964). He was acutely interested in the further explorations of the Highlands after the war and he was anxious to supplement the Museum's older collections with new material from there. To this end he corresponded with the Australian Administration in New Guinea and set up a number of contacts with both government and private individuals through whom he could organise the collection of artefacts.

South Australia has a peculiar association with Papua New Guinea. The ranks of missionaries, traders and government officers who have lived in the region all seem to have been swelled by South Australians. The consortium of business men who set up Guinea Gold N.L. to first exploit gold dredging at Wau-Bulolo and then developed the famous Guinea Airways came from Adelaide (Idriess 1933: 142, 209). Many of these people donated or sold material to the Museum as they travelled back and forth. Tindale recognised and tapped into this traditional Museum resource and cultivated enough interest to ensure a steady supply of incoming ethnographic material from the newly opened up areas in New Guinea.

Of the 800 or so collectors who donated or sold Pacific material to the South Australian Museum, only about 10% assembled collections of significant size. Missionaries are heavily represented, particularly with respect to the Papua New Guinea collections, and specifically Lutheran missionaries, or people of German descent linked to the Barossa Valley (Jones 1993: 24). The Lutherans penetrated the New Guinea Highlands as early as 1929 and pioneered missions further and further west, almost on the heels of the first European explorers. One of the most significant donations to the Museum came from the Lutheran Pastor A. P. H. Freund, who pioneered missions at Yaramanda in the Enga Province and Menyamya in the Morobe Province between 1948 and 1953.

Freund's Early Background

August Paul Harold Freund was born near Eudunda on 6 July 1907. His parents were Johann and Anna Christiane (nee Fiegert). Johann had taken up virgin land in the low rainfall area near Mount Mary, west of Morgan, in 1887. Johann and Anna had nine children and Harold, as he became known, was the second to last.

Harold worked on his father's farm until 1925, when he was seventeen and a half years old, then he enrolled at Concordia Lutheran College and Seminary in Unley. He met Dora Ey whilst teaching Sunday School at the Bethlehem Church in Flinders Street in 1928. He graduated on 8 December 1933 and married Dora on 6 April of the following year in the Zion Church in Gawler. His first posting as a Pastor was to Arno Bay on Eyre Peninsula, where he was responsible for fourteen Lutheran communities (Freund 1989: 38).

There were two Lutheran churches in Australia at this time and it wasn't until 30 October 1966, that they united. Freund belonged to the Evangelical Lutheran Church of Australia (ELCA). The other was the United Evangelical Lutheran Church of Australia (UELCA), which had been involved in supporting missionary work in New Guinea since 1886 when the missionary Johannes Flierl arrived there. After Freund became a Pastor the ELCA decided to realise a long standing ambition and also got involved in missionary work in New Guinea.

The Mission On Umboi

Freund was one of four ELCA missionaries called upon to go into a non-mission area on the upper Sepik River. They travelled to New Guinea on the 'Macdhui', arriving in Port Moresby on 27 December 1935. However, while Freund and his companions were attending the annual mission conference at Finschhafen, the Lutheran Mission Finschhafen offered to cede their interests in the Siassi Islands, off the western end of New Britain, to the ELCA and also sell them their mission station at Awelkon on Umboi (Rooke Island). The Lutheran Mission Finschhafen was heavily involved in opening up new fields in the Central Highlands and found that its resources were being stretched by maintaining the Siassi Mission. For the purposes of the Property Trust Ordinance, Freund's group named itself the Australian Lutheran Mission (ALM) and he and Dora settled at Awelkon on Umboi at the end of 1936. The ALM saw the Siassi area as an excellent place to gain the necessary experience needed for later extending its activities to the mainland (Wagner & Reiner 1986: 255). Subsequent events were to delay those plans for some time.

On 6 May 1938 their first son, Martin, was born and on 16 June 1939 their second son, Roland, was born. In September of that year war broke out in Europe and in December 1941, the Japanese attacked Pearl Harbour.

The Allies had been mindful of Japanese aggression in South-East Asia and China for some years and were aware that the so-called Japanese fishing boats operating off northern Australia and New Guinea were in fact spying and preparing coastal mapping. German raiders had also begun sinking allied shipping in the Pacific and had landed the crew and passengers off several sunken ships at Emirau Island north-west of Rabaul.

Awelkon had a good view of Vitiaz Strait through which ships from South East Asia had to pass enroute to Port Moresby and Australia. In 1940 Eric Feldt recruited Freund as a Coastwatcher. Harold was the only clergyman recruited to the Coastwatchers and his decision, though it was made quickly, must have been extremely difficult. He did acknowledge, however, that the Teleradio 3B, which Feldt supplied, was very useful because Awelkon did not then have any contact with the outside world except by sea mail. When he returned from accompanying Dora and their sons to Adelaide, where she had gone for medical treatment, he also brought back 'a very fine but not too bulky' telescope (Freund 1989: 43).

The Second World War

After the attack on Pearl Harbour, Freund's involvement in the war rapidly escalated. Dora and the boys were evacuated to Australia on Christmas Day, 1941; they were among about 2 500 women and children evacuated in the space of about a week. Freund and several other Lutheran missionaries, all with German surnames, joined the New Guinea Volunteer Rifles at Lae on 18 February 1942. Harold was technically exempt but valuable because of his expertise with the Teleradio and he agreed to join up also. There was no medical examination, no training, no uniforms or identity tags and the oath was makeshift. He was given a rifle taken from the disbanded police force but 'misplaced' it soon afterwards.

In March of that year, Freund was involved in a dangerous sea-going rescue of the remnants of the Rabaul Garrison, organised by J. K. McCarthy who was then the Assistant District Officer (ADO) at Talasea. McCarthy collected the pitiful survivors from the garrison together using his New Guinea police and the group that Freund was in took four small boats over to collect them (Freund 1989: 54). This episode and Freund's role as a Coastwatcher would later hold him in good stead with the Administration, particularly when McCarthy became the Director of the Department of Native Affairs.

Freund was eventually discharged in Australia in July 1943 after 484 days of continuous active service, including a strenuous and dangerous walk through Japanese occupied country on the New Guinea north coast to Bena Bena in the Highlands near Goroka, whence he was flown out to Port Moresby.

In November 1946, Freund helped take a new mission boat, the Umboi-2, from Sydney to Umboi to resume mission work. The Japanese had occupied the mission and he spent 18 months getting Awelkon back in shape and the mission work going again.

In 1948 the Lutheran Church – Missouri Synod, USA, decided to launch into mission work in New Guinea. They had chosed the densely populated Wabag Valley as their field and approached the ALM for assistance during the establishment period. Freund and 'Pat' Kleinig were detailed to render that service.

European Exploration Of Enga Country

It is difficult to pinpoint when the Enga first came into contact with Europeans. William McGregor penetrated the Highlands from the Sepik as far as the lower Maramuni and returned via the Yuat in 1928. On this expedition he met people who would most certainly have been outlying Enga. The Fox brothers, Tom and Jack, explored an area west of Mount Hagen in early 1934 but their route is unclear (Taylor 1938–9).

The Enga's first major encounter with Europeans occurred in mid 1934. An expedition led by the tough and experienced prospector, Michael Leahy, had left Kuta, near Mount Hagen, on 11 June to explore the country west to the Dutch border. Leahy had been unsuccessfully seeking a major goldfield for many years and this area was the last largely unexplored region in New Guinea.

Leahy's initial dealings with previously uncontacted people in the Highlands had been relatively peaceful. A general belief that the prospectors were either the ghosts of departed ancestors or supernatural beings from another world had paved the way for largely unmolested travel. It was only when the truth became known that clashes occurred and these incidents were swiftly dealt with by Leahy and his men using their high-powered rifles.

The Enga were familiar with the concepts of

exploration and settlement well before they encountered the first European explorers. Their more spiritual accounts of evolution from 'sky people' are tempered by oral traditions of their own colonisation of the country by ancestors who came from the west and south-west (Bulmer in Lawrence & Meggitt 1965: 134). This pragmatic appreciation of such a concept made the Enga's reception of European explorers into their country quite different from that accorded by other Highland groups. While the Europeans were confidently expecting the Enga to be initially overawed by their presence and unlikely to be aggressive, the Enga were, in fact, simply confused and unsure about how to treat the newcomers. This confusion predisposed many of the Enga's first encounters with Europeans to unfortunate outcomes characterised by unprecedented violence.

On 25 June 1934 at a place called Doi, a few kilometres west of Wabag, a particularly bloody encounter took place which resulted in the deaths of fifteen Enga and the wounding of many more. While Leahy and his party were camped at Doi, the Enga there had engaged in a heated debate about what to do about them. One of the Enga leaders had argued that the strangers should be sent on their way as soon as possible. This man, named Pinketa, had quite unexpectedly urged the group of people below Leahy's camp to attack. Leahy had watched this event unfold and had shot Pinketa as soon as he began brandishing his spears. As soon as he fired, the rest of his men followed suit, firing indiscriminately into the crowd hitting both men and women. Further shootings occurred as the Leahy party progressed westwards and only ceased when Michael's brother, Dan, became ill with malaria and the decision was made to abandon the expedition and return to Mount Hagen.

Michael Leahy duly reported the incident at Doi to the Administration, which took no action against him. However, at a later lecture before the Royal Geographical Society in London, Leahy recounted the Doi incident and caused a furore which forced the Administration to further investigate the matter. This investigation endorsed the Administration's earlier finding but subjected Australia to much international criticism.

The miners Schmidt and Schultze attempted to follow Leahy's path soon after his return. They reached the Sepik via the Yuat but it is unclear where they actually went in between. Ludwig Schmidt became the first white man to be hanged in New Guinea following the reports of atrocities he committed against local people on this expedition.

When two Catholic missionaries were killed in the Chimbu area in late 1934 and early 1935, the Administration finally decided not to issue any further permits for miners or missionaries to enter uncontrolled areas and to severely restrict the activities of those already there. This effectively cut off the Enga from further incursions for several years (Connolly & Anderson 1987: 214).

Inevitably, this closure of the area west of Mount Hagen soon precipitated calls to open it up again. In both Papua and New Guinea various consortiums were looking for petroleum. The area around Wabag was of particular interest to these groups, for no other reason than the fact that they couldn't gain access to it. In 1938, partly as a response to this pressure, a large Administration patrol, under the leadership of Assistant District Officer Jim Taylor, with Patrol Officer John Black and Medical Officer, C. B. Walsh, set out to explore the area of Michael Leahy's aborted expedition west of Mount Hagen.

The Enga acccorded the Taylor patrol quite a different reception to that received by Michael Leahy, although Taylor persisted in believing that the Enga saw his party as the returning ghosts of their ancestors. It is interesting to speculate how much the Enga had learned about the Europeans in the intervening years. The Enga had trade contacts with the Medlpa, close to Mount Hagen, and must have picked up a lot of useful information by this means. When Taylor walked along the Lai Valley he noticed quite a number of steel axes which presumably had been traded in from the Mount Hagen people.

Taylor was initially wary of the Enga but gradually came to trust them.

> When the people got to know us they liked us, only when we are the unknown quantity are they suspicious and unfriendly (Taylor 1938–39: 42).

He was also impressed by their sophisticated gardens, wide, well drained and graded tracks and substantial bridges. On the Waga he noticed two young casuarina trees deliberately planted so that they could be used as bridge pylons when they matured. He camped at Doi (Tore) where he found the people

> bright and friendly and apparently bore no malice, realising, I imagine, that the trouble was their own making. They appeared quicker in the uptake than those down the valley and had more to say (Taylor 1938–39: 44).

Taylor was searching for a suitable site for a base camp and airstrip:

> On the 21st July we drew in to Wabag, on a high terrace with a good depth of black soil, above the right bank of the Ive (River) Lai, not far above its junction with the Ambum. The area was inhabited by two groups known as Kulliner and Man-gia.
>
> I explained to the people what we were going to do, through Leo, who was now our best interpreter. He made an eloquent speech which impressed the people, or so it appeared to me, for they listened in silence and at its conclusion struck the ground ecstatically with their stone axes and told us to carry on. I think they wanted to see the aeroplane.
>
> We began immediately preparing a landing ground on a stretch about 800 metres long by 40 metres wide. It was on a gentle incline but was covered in wild sugar-cane which meant a lot of cutting, grubbing and burning.
>
> . . . on the 8th August at 10.25 a 3-engine Ford, pilot T. O'Dea, landed on the ground. People flocked to the camp from every direction, there was much singing and dancing. O'Dea was a great success as he always is with inland people. From 1932 he has worked with us in all parts of the plateau, and being a singer of no mean order the people shriek with delight when he sings to them songs from Pagliacei, Cavalleria Rusticana and Tosca. They love to see a white man act as a human being (Taylor 1938–39: 75–78).

Despite the apparent friendliness of the Wabag people, an attack, in which a Police bugler was killed, occurred at Wabag two days after Taylor had left with the main party for the Sepik. The boy bugler was with a party sent out to buy pigs. He became separated and was brought down with a stone axe. During the rescue of the party, led by Sergeant Fokinau, two police and four carriers were wounded and about eleven Enga killed. Medical Officer, C. B. Walsh, radioed the Administrator and the District Officer from Morobe, Edward Taylor, flew in and succeeded in defusing the situation.

In September, while Taylor was still away on the Sepik, Patrol Officer Ian Downs went to Wabag and began a series of local exploratory patrols. Among other places, he visited the Tarua and Sau, tributaries of the Yuat, with Walsh. During a visit to the Lai Valley, Downs noted that the valley between Yaramanda and Link 'is out about with tribal disputes which have left a trail of desolation'.

Later, Patrol Officer Lloyd Pursehouse (who was with Freund during his time as a Coastwatcher and was later killed by the Japanese) replaced Downs and accompanied Walsh to explore the upper reaches of the Lagaip. On 17 April 1939, after Black had returned from an expedition to Telefomin, the New Guinea Administrator, Sir Walter Ramsay McNicoll, flew in to Wabag and stayed overnight. About three thousand Enga came in to Wabag to meet him.

Taylor and his party left Wabag on 7 June 1939, following an Enga trade route to Mount Hagen which Patrol Officer Murray Edwards had been shown. On 18 June they reached Mount Hagen and met Patrol Officer George Greathead at the head of a road he was building to the west.

A number of Patrol Officers using the route pioneered by Edwards made sporadic visits to Wabag after Taylor returned. In 1942 a permanent Patrol Post was set up there by ANGAU officers. Expatriate refugees walking inland from the northern coast to escape the Japanese often made for Wabag and then Mount Hagen.

By 1960 three other Patrol Posts had been established in neighboring valleys. In 1973 the Enga area became a district in its own right and is now one of the nineteen provinces of Papua New Guinea (Sinclair 1981: 160).

The Mission At Yaramanda

A Seventh Day Adventist pastor, L. A. Gilmore, visited Wabag in 1944 as a Paramedic with ANGAU following reports of an outbreak of Bacillary Dysentery amongst the Enga. The dysentery had been introduced into the area by soldiers passing through Wabag and was one of the first Engan introductions to the more subtle and unpleasant aspects of European intrusion into their country. Two Seventh Day Adventist pastors, Frank Maberly and Laurence Howell, flew into Wabag on 4 June 1947 to set up their first mission at Rakamanda (Kopamu 1994: 29). The first Catholic mission in the Enga area was set up at Pompabus, a few kilometers outside Wapenamanda, in February 1948 by Father Gerry Bus and Father William Ross of the Society of the Divine Word. They had flown into Wabag in October the previous year to make arrangements for the mission with Patrol Officer B. Macillwain (Kruczek 1995: 18).

In 1947 the westernmost Lutheran mission was at Ogelbeng near Mount Hagen in the Western Highlands District. Rivalry between the missions in New Guinea had always been fierce. The Lutherans, Catholics and Seventh Day Adventists were particularly competitive and, despite a number of inter-denominational meetings to discuss and resolve the problem, the poaching of

converts and districts was rife (Flierl 1937: 22). Since the Catholics and Seventh Day Adventists had already entered the Wabag Valley the Lutherans knew they had to move quickly to stake a claim in the area before the other missions expanded their influence too far.

The Lutheran party, comprising Freund, Reverend Felix Doering and lay worker Armin (Pat) Kleinig headed for the vacant mission area at the eastern end of the valley and for this reason they decided to go overland using the well worn track between Mount Hagen and Wabag. They left Ogelbeng on 23 August 1948 with 230 carriers and reached the Wabag Valley three days later. The local Laiapu Enga people had selected a site for the mission which did not appeal to Freund and his party and they carried on past it for a few kilometres until they came to a knoll on neutral ground at the boundaries of three different clans. The spot was near the abandoned police post at Pausa, overlooking the Lai River. After the Enga had agreed to the site, which was called Yaramanda, Freund and Felix Doering walked the 50 kilometres to Wabag to seek approval for the mission site from the Administration. Dora and their two sons arrived at Yaramanda in December (Freund 1985: 117).

At Yaramanda, Freund saw the complex travelling *Te'e* festivals where pigs and other valuables were paid out to cover debts. He also saw initiation ceremonies where young men received their first wigs. The richness of the Engan culture fascinated Freund and he took the opportunity to learn more about it. During this process he began to acquire a number of artefacts.

The Enga People

The Enga are now generally divided into clans, but in Freund's time the patrilineal tribe was still significant. The clans within the tribes divided into sub-clans and lineages and lived in hamlets. There are cultural differences between the Western and Eastern Enga. The Western Enga are divided into the Mae and Yandapu and the Eastern Enga into the Syaka (or Kyaka) and Laiapu. The latter group is centred around Yaramanda. The population density of these four groups exceeds 150 people per square kilometre. On the fringes of the groups the density is much lower, averaging less than forty people per square kilometre. In total there are approximately 250,000 Enga, making them the largest linguistic group in the whole of Papua New Guinea.

The vast majority of the Enga are bush-fallow cultivators, with sweet potato and, to a lesser extent, taro as staples. Pigs formed the basis of Enga wealth and were supplemented with shells, salt, stone axes, net bags, skirts and tree oil. The elaborate exchange and debt system (*Te'e*) involving these valuables was the element which provided social cohesion for the Enga. The same system, called *Moka*, was used further east around Mount Hagen by the Medlpa people (Kyakas & Wiessner 1992: 130).

Since the 1950s the Enga, as with other Highlanders, have been major subjects of anthropological study; see, for example, Brennan (1970), Brown (1978), Freund (1969), Sillitoe (1988) and Kyakas and Wiessner (1992). Enga culture, including its material culture, has been described in detail in almost every aspect. The literature is extensive and readily accessible to both the academic and lay reader. It is useful, however, to look briefly at the descriptions of the Enga provided by Jim Taylor when he first entered the area in 1938.

> Boys go naked to about 10 years and girls to 3 or 4 years when they wear a small net covering. When a girl reaches puberty she puts on a rush skirt which is called *kwerra*; the rushes are grown in small ponds very often made artificially for the purpose. When about 3 feet high and turning white the plants are taken out or cut and the rushes flattened and made into tapes. These are made into skirts which reach to just above the knee in front and hang almost to the ground resembling a horse's tail, at the back. The ends are trimmed, being made perfectly even and the skirt is open at the side to give the leg free movement. They are white in colour and not unattractive in appearance.
>
> As the boys grow up they wear several nets folded double over a belt of waist strings and reaching to the shins. A bunch of lily leaves (*Cordyline terminalis*) form the posterior covering of the men.
>
> Women wear their hair short and cover their heads with a net shawl edged with white beads of Job's Tears. A string bag is knotted on the crown of the head and carried on the back. Though this is for use it is also an article of apparel, and no woman would walk abroad without one.
>
> The men allow their hair to grow long and wear it in a mop, sometimes turbaned with tapa cloth. The hair is cut with bamboo knives and large wigs of two patterns are made, the mop and the cossack type. The small cowrie is the principal decoration, and necklaces are worn and the shells threaded from side to side and sometimes in rosettes. The women prefer however the white and grey beads known as 'Job's Tears' which they grow in the garden. Huge

necklaces are wound hundreds of times around the neck and carried on the shoulders. Older men wear beards and are very proud of them. Combs are unknown and the hair is dressed with a single prong.

The staple food is the sweet potato, and beans, cooking bananas, native spinach, taro, yam and sugarcane together with nuts, seasonings and other vegetable foods obtained from the forest, make up the diet. Pork is the principal meat food but this is augmented by opossum, field rats and eels . . . Dogs are not eaten and fowls are unknown. Ginger is used as a stimulant and tobacco is grown, but is smoked only by full adult men.

Settlements are usually of two or three houses placed close together. A man's house where men of the family sleep and women's houses for the women and girls . . . The houses are well-built but are small affairs about 24 ft x 8 ft and 6 to 10 ft high, the rear end of the houses being about 4 ft higher than the front. Walls are 5 ft high and are made of pickets and pandanus leaf. The frame is of wood and the roof of coarse grass (kunai) where obtainable, and the stalks of reeds where it is not. Inside, the men's houses consist of one room devoid of luxury. Women's houses are divided into three, a living room at the front where meals are eaten; the men come to meals; stalls for pigs and a bedroom. The inmates sleep on mats on the ground and fires are kept burning in fire-places made of clay and stone all through the night. They are warm and dry and very suitable for the climate, but are made uncomfortable by smoke and the common flea (Taylor 1938–39: 141–2).

Taylor described the Enga religion in fairly simplistic terms: a goddess, Yemborne, and a god, Tai, descended from the sky and taught the Enga 'arts and crafts' and then ascended again and remain watching over them. Taylor also alludes to the worship of sacred stones, which are guarded closely. This is similar to a belief amongst the Hagen people called *Kur* (Taylor 1938–39: 143).

The Enga focus their religious beliefs both on the 'sky people' and on the spirits of their ancestors. Keeping both groups happy and placated is believed to be the source of harmony in the Engan world and a number of special feasts are held in their honour. The 'sky people' were created by Aitawe, represented by the sun, and dissociate themselves from earthly concerns except on a grand scale, such as in matters related to weather, earthquakes and land-slides. They have a loose connection with the ancestors and their existence and influence is celebrated in a range of colourful myths (Kyakas & Wiessner 1992: 136).

As noted above, pioneering the Lutheran mission work in the Wabag Valley was a joint enterprise between the ELCA and the Lutheran Church-Missouri Synod. However, when the Executive Secretary of the Board of Missions of the Lutheran Church – Missouri Synod, Dr. O. H. Schmidt, arrived at Wabag with the Synod's first missionaries, Willard Burce and Otto Hintze, he announced that the joint enterprise was not to continue. On this basis Kleinig returned to Siassi towards the end of 1948. Freund and his family stayed on helping Burce and Hintze until 22 June 1950 before going back to Siassi. Both Freund and Kleinig were destined for more pioneering work elsewhere, this time amongst the Kukukuku.

European Exploration Of Kukukuku Country

Whether deservedly or not the Kukukuku had the reputation as the most dangerous, aggressive and savage tribe in the whole of Papua New Guinea. The stocky little fighters raided as far south as the Papuan Gulf and in 1906 the Administrator of British New Guinea, Captain F.R. Barton, established an administrative outpost on the coast at Kerema principally to curb their depredations. When not raiding their neighbours the Kukukuku fought amongst themselves and when the first Europeans penetrated their boundaries they took them on too (Sinclair 1966: 7).

The famous 'Outside Man', Jack Hides, described the daring of the Kukukuku as 'colossal' (Hides 1936: 202). District Commissioner and planter, Ian Downs, whose adolescent Kukukuku interpreter had been presented to him one morning disembowelled and impaled in sections on the defensive stakes of his camp boundary, was less sanguine in his praise. He later described the chill he felt when he momentarily mistook the shaven heads of Hare Krishna in the streets of Sydney for Kukukuku (Downs 1986: 8).

In some instances the Kukukuku's reputation preceded them; a report in the 'Illustrated London News' in 1931 attributed the murder of pilot Trist at Zenag to the Kukukuku when it is well known Zenag is well out of their territory. I suspect this article was written by Ion Idriess and it is possible he confused Zenam, a base camp on the Isimb River in Kukukuku country, with Zenag. Trist had, in fact, crashed into a mountain and been killed. Local people led the search party to the crash site.

Captain Detzner, of the German Administration at Morobe, is thought to have been one of the first Europeans to penetrate Kukukuku country. He

entered the area south of Wau when he was in hiding following the Australian military annexation of German New Guinea in September 1914. Resident Magistrate W. R. Humphries patrolled the southern fringes of the area out of Kerema at about the same time and about 1928 a group of prospectors, including Soldwedel, Zacharov and one of Detzner's old soldiers, Helmuth Baum, are known to have reached an area south of the Upper Watut. By 1930, Australian Administration patrols led by such officers as E. Feldt, N. Penglase and A. Roberts, were regularly entering the area from the Otibanda Patrol Post on the Upper Watut (Hurrell 1951: 17).

In 1931, Helmuth Baum and eight of his Buang carriers were killed in the Kareeba-Indiwi area. In the same year Mick and Pat Leahy were attacked near the Langimar River and both were injured; Mick felt the effects of a club blow to his head for the rest of his life. In 1932 the prospectors Emile Clarius and Bill Naylor, with seven Buang carriers, were killed at Kobakini near the Kapau River. Naylor and Clarius were attacked as revenge for the men taken away to gaol and presumed dead after arrests were made following the murder of some Kukukuku women in inter-tribal fighting.

Patrol Officer Bridge found the bodies of the prospectors but failed to apprehend the murderers, as did a subsequent patrol. J. K. McCarthy, returning from a patrol in the area, made a third attempt and was attacked and wounded. He was ill-prepared for the arrests, carrying neither handcuffs or leg irons and, as it transpired, only captured one of the men involved in the murders of the prospectors. His unfortunate police were tied by ropes to the prisoners and caught the full brunt of the Kukukuku attack. Three innocent Kukukuku were killed during the arrests, two died in the attack and another two attacking the patrol were shot dead. Six police were injured, including Corporal Anis, who was shot through a lung with an arrow and later died. None of the carriers were fired upon by the Kukukuku (McCarthy 1933: 12). Subsequent published accounts of this incident portray the Kukukuku as bloodthirsty ambushers but McCarthy's original patrol report belies that version.

Following this patrol McCarthy made a glowing report of the gold prospects in the area and convinced the Administration to set up an airstrip there for the purpose of allowing prospectors access. He returned there in September 1933 with Cadet Patrol Officer John Black, a South Australian who later accompanied Taylor on the Hagen-Sepik Patrol in 1938–9, and Surveyor George Ballam to set up a base camp and build the airstrip.

McCarthy chose a river flat which he had seen on his earlier patrol at the junction of the Tauri (Kotai) and Yakwoi Rivers for the site of the airstrip. The nearest village to these flats was on a ridge to the west and was called Menyamya. McCarthy adopted this name for his base camp. The river flat was strategically placed between the warring Gainyama and Etobanga Kukukuku, and neither group permanently occupied it (McCarthy 1963: 120).

Patrol Officers John Costelloe and Murray Edwards (who had recruited Down's unfortunate interpreter) had both been driven away from the Menyamya area by the Kukukuku but had not sufffered casualties and McCarthy felt that once he had an airstrip built it would be possible to allow miners into the area. To the momentary amazement of the Kukukuku, Tommy O'Dea, the manager of Holden's Air Service at Salamaua, flew a De Havilland 50 biplane with a single 450 horse power Jupiter motor into Menyamya on 3 September 1933. The Kukukuku obviously took this event in their stride because one of the men Tommy O'Dea flew out to Salamaua to see the ocean led an attack on one of McCarthy's patrols two weeks later and was shot dead (Simpson 1962: 44).

Over the next few months prospectors entered the area by aeroplane and under the protection of McCarthy and the other Patrol Officers there they investigated most of the surrounding country (Black & Bridge 1934: 10). The Kukukuku were mystified by these incursions and occasionally attacked McCarthy's patrols. McCarthy's optimistic predictions about viable gold deposits in the area quickly proved fruitless however and the Administration told him to close down the base camp. New areas were being opened up to miners in the newly discovered valleys of the Central Highlands and the Administration had decided to concentrate its efforts elsewhere (McCarthy 1934: 3; Sinclair 1966: 8).

In 1936, the Lutheran missionaries Lechner, Reiner and Maurer explored the country south of the Wau and Bulolo goldfields. They reported significant populations and received approval from the Administration to enter the area but not to set up missions. At the same time, Patrol Officer A. T. Timperley, working out of Kerema, established a temporary patrol post on the Upper Tauri close to the Papuan border.

The Kukukuku continued to harass the sporadic patrols which entered their territory over the next seventeen years. Ian Downs was driven out of the Kobakini area where he was endeavouring to set up a base camp in 1937 and he was again attacked at Imisi on the Upper Banir by the Siminapa Kukukuku in 1947. Downs reported that the Kukukuku had their own unique humour,

> a theatrical pantomime of denials that they had ever attacked us followed by tearful demands for the return of their arrows (Downs 1986: 4).

By the 1950s the pace of development had markedly quickened in Papua New Guinea, particularly with the influx of planters into the Central Highlands. In 1949 the Chifley government had been defeated by Robert Menzies and the United Nations had approved the administrative union of Papua and New Guinea, with Port Moresby as the permanent capital. In 1950 a system of Native Local Government Councils was inaugurated and the Administration prepared itself for the first United Nations Visiting Mission (Downs 1980).

Buoyed along by these rapid changes and encouraged by the general post-war optimism, the Administration, under Colonel Murray, set the elimination of restricted areas in the Territory as a major goal (West 1968: 69). In 1950 the decision was made to reopen Menyamya. Assistant District Officer Doug Parrish and Cadet Patrol Officer Garry Keenan were assigned the task but at the last moment Doug Parrish broke his wrist and was replaced by Assistant District Officer Lloyd Hurrell. Hurrell was a dedicated and tough officer who had been shot in the legs during the war but had refused to discontinue patrolling.

Hurrell and Keenan left Slate Creek on 31 October accompanied by 157 carriers loaded down with over two tons of food and equipment, guarded by thirteen police and accompanied by an interpreter and medical orderly. The patrol reached Menyamya early on the morning of 9 November, 1950 and immediately began clearing the old airstrip. Soon De Havilland 84 biplanes from Lae began to arrive on a regular basis (Sinclair 1981: 75).

Two months later Hurrell felt confident enough about the situation at Menyamya to bring his wife Margaret and their two children Peter and Lesley to live there. Whether intended or not this was a turning point in the Administration's relationship with the Kukukuku. Suddenly the Kukukuku saw the strange white invaders in a new light; they were normal human beings, just like them, with wives and children! Young Lesley Hurrell, who had pure blond hair, was of particular fascination to the Kukukuku and they delighted in her presence (Sinclair 1966: 12).

The Mission At Menyamya

In early 1950, the ELCA Mission Board Secretary, who had heard reports of what appeared to be large populations in the area from commercial pilots, had flown over the Kukukuku country to confirm these reports. When Freund and Kleinig returned to Umboi they were invited to attend a Lutheran Convention at Busamang (on the coast between Lae and Salamaua) where it was decided that Freund should lead a mission into the Kukukuku country. On 24 November 1950, with Rev. Georg Horrolt and Rev. Fred Scherle, Freund flew to Menyamya to assess the situation and discuss the establishment of a mission with Assistant District Officer Hurrell.

Hurrell had been quick to recognise the proposed mission as another opportunity to consolidate the headway he was making with the Kukukuku. He was delighted when the Administration quickly approved the Lutheran application, noting that one of the missionaries, Pastor Freund, had seen military service during the war, a fact which he thought influenced the Administration's attitude to the proposal (Hurrell 1996).

Menyamya was classified as a Restricted Area, however, and it was necessary for the missionaries to also apply for permits to enter the area. Freund's sons were ready to begin their secondary schooling and since he was due for furlough Freund thought that the period spent waiting for the permits could be used to settle them in their Australian school. On this basis he travelled with his family to Australia by boat in early 1951. The permits were approved within six weeks, however, and Freund, for the first time, travelled by aeroplane back to New Guinea.

The Menyamya advance party consisted of Freund and Horrolt. Horrolt was an experienced missionary who had assisted in setting up the Lutheran Mission at Ega in the Chimbu in 1934. Accompanied by one church elder and two servants they arrived on 13 March 1951. Freund has said 'this date may eventually be regarded as the date of the beginning of our mission work in the Menyamya area' (pers. com.). Hurrell provided a hut for Freund and his party and even supplied meals. Freund and Horrolt identified five

acres for the mission and 120 acres for gardens and stock on a knoll across the river from the Administration station and arranged with Hurrell for its purchase.

Freund and Horrolt were soon joined by Scherle, Kleinig and school teacher Owen Altus. It took nine Dragon Rapide plane flights over a two week period to transport the personnel, stores and equipment for the mission station from Lae to Menyamya. Freund recorded in his diary the fact that the plane could only carry 1200 lbs [544 kg] per trip and the 55 minute flight each way cost 28 Pounds [$56].

The personnel included twenty evangelists from the Lutheran's coastal stations, three accompanying elders and two servants. The Lutherans worked on the principle of the 'self-propogating Native Church' by sending out Papua New Guinean evangelists. These evangelists were seen to be more readily admitted into new territory than European missionaries (Frerichs 1957: 16). Freund discussed this approach with Hurrell and they agreed that sending out evangelists amongst the Kukukuku at such an early stage would not be safe. Consequently over half of the evangelists were returned to the coast.

At first Hurrell placed a two mile limit out of Menyamya on the mission staff and a five mile limit on Freund, but this gradually increased as time went by. Hurrell (pers. com.) also enforced the rule under the Restricted Areas Ordinance that parties venturing outside the mission had to be armed and Freund concurred, although he wondered what the Administration would have done if he, as a missionary, had actually shot anyone, not to mention what the rest of the world might have thought.

Owen Altus was recruited for Menyamya because the Lutherans were convinced that education had to be a basic aspect of their mission work. Hurrell got on well with Altus and the two men are now related through a family marriage. Hurrell also thought Fred Scherle was a good influence at Menyamya and he developed a lasting friendship with him also. Georg Horrolt, on the other hand, did not settle into Menyamya as well and left.

The missionaries bought building materials from the Kukukuku with bush knives, axes and shells. The women brought in sweet potato and corn to sell and these were also bought. Freund weighed one woman's load at 38 kg, which she carried with a baby over 17 km. Another woman weighing 47.6 kg brought in a loaded *bilum* (string bag) weighing 52.2 kg from 4.8 km away. Initially the women kept their bark cloaks drawn around them and were always accompanied by a bodyguard. Later they relaxed and came to the station by themselves (Freund 1985: 146).

Freund brought the first cattle into Menyamya on 25 November 1952 and the first calves were born in October 1954. On 26 February 1955 Deaconess Merna Thamm arrived to work amongst the women. Reverend T. W. Lutze established Kwaiguma station, about fourteen kilometres east of Menyamya in 1951. Freund helped Reverend Russel Weier start the Kwaplalim station, about fourteen kilometres west of Menyamya, in September 1957. Ken Cramer established his medical centre at Womgaga, not far from Kwaiguma, in 1960. In 1962 a station was established near Eyokaga, about ten kilometres north of Menyaymya. This station was called Concordia, partly in honour of the Lutheran college in South Australia but principally because of the difficulty of rendering an accurate spelling of the local Kukukuku name for the site. A road was built from Menyamya to the station and the Freunds moved out there on 16 June, 1964.

Menyamya was a pleasant spot for the Freunds. It is located about 120 km west-south-west of Lae, with the airstrip at 1 128 metres and the surrounding hills up to 2 438 metres. The rainfall is consistent all year but varies between 1.1 and 2 metres per annum. The usual temperature range is from about 16 to 29 degrees, although in May the overnight temperature has been known to drop to 2 degrees. The warmth is tempered by a breeze blowing up the valley in some months and down in others. Fogs, which are a nuisance to pilots throughout New Guinea, are rare at Menyamya.

The Kukukuku People

The term 'Kukukuku' is not one familiar to the people it purports to describe. The general consensus is that the word is derived from the Motuan *kokokoko*, which is the word for cassowary, and describes the distinctive cassowary-bone belts worn by Kukukuku men after the birth of their first child. Other connotations are more derogatory. In a letter to Tindale dated 15 October 1951, Freund noted that the term caused offence to the Menyamya people. Pressed further, Freund reported that the Menyamya Kukukuku referred to themselves as *Ngwodiaga* but did not provide any further information. A more colourful, and predictable, version of the term comes from the Upper Watut

people who say that the first Patrol Officer, when asking them who they were, mistook what a man said when he replied '*kouka*', their word for man or boy (Burton 1996: 2). Simpson (1962: 19) reported that the Bulolo people referred to the Kukukuku as the *Babwaf* or *Babwa* but this is the name of a village on the Watut River (McCarthy 1933: 5).

Faced with this dilemma in terminology, a number of researchers, including Lloyd and Gajdusek, proposed the word *Anga*, which is almost universally used by the Kukukuku to describe the concept of 'home'. The word has caught on with some researchers but is, according to the Curator of the J.K. McCarthy Museum in Goroka, Ivan Mbaginta'o, who is himself Kukukuku, not in common usage amongst his people. Mbaginta'o, however, uses the term Anga in his own publications. Since this paper is principally concerned with the historical context of Freund's collection, rather than its anthropology significance, I have opted to maintain the older term.

Hurrell and Keenan estimated there were about 22 000 Kukukuku living within a radius of sixteen to twenty kilometres of Menyamya in 1951, with a strip of land about 20 kilometres wide all around designated 'no man's land' (Keenan 1952: 6; Freund 1985: 138). The northernmost part of their country is the point where the Langimar River joins the Watut, which eventually links with the Markham River and flows into the sea near Lae. Their southern boundary extends almost to the Gulf of Papua in the vicinity of the Lakekamu River. Mount Yule marks their eastern boundary and the Vailala River their western boundary. Their present population is in the vicinity of 70 000 – 75 000 (Hallpike 1978: 1; Hides 1936b: 8; McCarthy 1963: 90).

Much public interest was created in Australia and overseas in the Kukukuku following the publication of W. R. Humphries' 'Patrolling in Papua' in 1923 and especially after a series of books by Jack Hides, one of the so-called Papuan 'Outside Men'. A number of striking photographs of the Kukukuku taken by Patrol Officer G. F. W. Zimmer and published in the Papuan Report (1925–6) were also reproduced in a number of popular journals both in Australia and overseas in 1927 and were later used by Zimmer himself to illustrate an article in the *Pacific Islands Monthly* (Zimmer 1969: 85–93). The development of gold mining near Bulolo also focussed attention on the Kukukuku in the 1930s (Fisher 1936: 10). Unfortunately the primary fascination with the Kukukuku centered on the the myths that had evolved around their reputation as warriors. By the late 1960s this sort of public interest had waned.

Apart from Blackwood's early work, more scholarly publications did not emerge until the late 1950s when Craggs et al. (1958), Fetchko (1972), Fischer (1959, 1961, 1963), Godelier (1969, 1971, 1986) and others sporadically published a variety of monographs. Curiously, interest in the Kukukuku amongst anthropologists has, until late, never been as great as that in the Enga.

Possibly the best description of the Kukukuku at the time of initial contact comes from J. K. McCarthy. McCarthy's encounters in the 1930s were principally with Kukukuku men and he described their appearance in detail.

> Around their middle they wore a skirt of heavy grass fibre which hung to their knees in front; their buttocks were covered with a strip of beaten bark cloth and many wore belts of linked cassowary bones. Across their chests they wore cross-belts of bright yellow beads made from the seeds of a plant. On their left arms they wore the bowman's wrist covering to protect them from the cut of the relaxed string.
>
> The sides and front of their heads had been shaved by their sharp bamboo knives but a top-knot was left at the crown of the skull. From this was hung a cloak of beaten bark, which hung to the back of the knees. This covering - the *mal* – served two purposes, as a protection against the bitter winds and rain of the mountains when it was drawn tight around the wearer, or as a method of camouflage when they put it over their bodies and stood motionless. This camouflage was very effective – even close up you could not be certain whether it was a man or a tree stump you were looking at.
>
> Their bows were of blackwood palm, short but powerful, and the strings were of cane. The arrows were also short, undecorated and unbarbed, although some were heavily notched at their palmwood heads. Some too, had tips of sharpened bone while others had the wide sharpened blades of bamboo fitted. These last were generally used for pig-hunting, when the wide blade would cause the animal to bleed a great deal and so fall from exhaustion. A stone adze or stone club completed their arms, the clubs being masterpieces of workmanship. The polished stone heads followed several designs. Some were notched in small squares like a Mills Bomb; some were star shaped, some were cut like gear wheels. The more utilitarian clubs were plain globes about the size of a cricket ball and drilled through to take the wooden handle; others were flat circles of granite. The clubs were often carried hidden in their waist bands and

> covered by the long cloak that hung behind; they were able to jerk them out like lightning.
>
> Each man had the septum of his nose pierced and through it he wore a short piece of white bone or bamboo. Their expressions were almost always fierce and truculent. Even their language sounded as though the speaker was in a raging temper; the words began slowly but each sentence became faster so that at the end it was a high-pitched torrent. This description of tribal dress was common to all Kukukuku. It remained the same from the central ranges of New Guinea to the hinterland of the Papuan Gulf (McCarthy 1963: 97).

Beatrice Blackwood, who had carried out fieldwork amongst the Kukukuku of the Upper Watut River area, about 50 kilometres northeast of Menyamya, in 1936–7 provided an early description of the clothing of the Kukukuku women:

> The women wear a skirt which is fuller and longer than the men's sporran. The skirt has a back and front leaving the flanks bare. The skirt is made of shredded bark . . . Little girls begin wearing these skirts much earlier than boys begin wearing their sporrans. Tiny ones not more than an inch or two long are seen on babies who can scarcely walk (Hallpike 1978: 45).

Blackwood noted that the women also wore the ubiquitous bark cloak, fastened in the same way as the men's, as well as a variety of ornaments, including belts, necklaces and armlets, many of which featured the bright yellow stems of orchids (mistaken by McCarthy as seeds). The women did not pierce their noses but, like the men, pierced their ears and inserted the pliable wing shaft of a cassowary upon which, when bent back on itself and secured, served as a loop for suspending shells and other objects. The women, like the men, also carried small net bags for transporting useful items such as fire lighting equipment (Hallpike 1978: 46).

The Kukukuku, like the Enga, were bush-fallow cultivators of sweet potato and taro but they kept few pigs and did not have any exchange systems based on pigs, shells or other valuables. As a consequence they had no 'big men' or chiefs and their leaders were generally the more skilled hunters or warriors. They were sophisticated hunters, using bird-hunting platforms and elaborate traps. They were a part of several trade cycles and used clay pots which came to them from the Markham Valley via the Lower Watut (Hallpike 1978: 2).

Blackwood is somewhat dismissive of the Kukukuku's technological skills but this seems to be related to their disinterest in decorative art. Certainly, as Freund testifies, their skills in making the practical articles needed for daily existence, and particularly salt manufacture, were quite sophisticated.

This lack of interest in decorative art sets the Kukukuku apart from everyone else in Papua New Guinea and, indeed, the whole Pacific region. There are other distinctions also. The blood pattern found in a representative sample of 111 Kukukuku in the late 1950s did not resemble that reported from anywhere else in New Guinea. Thus Craggs et al. (1958: 70) suggested that the Kukukuku may represent a group of people distinct from both the Highland and the Coastal people of Papua New Guinea. The Kukukuku languages are also relatively distinctive. There are about 12 Kukukuku languages similar enough to form a linguistic stock but, on the basis of Wurm's 5 – 12% cognatic association rule, the Kukukuku speak a language which is quite different to that of their neighbours (Hallpike1978: 1). Lloyd (1973: 96) suggested that further work had to be done on the Kukukuku language before a definitive case could be made for its context in the Melanesian language family. Recent work by Foley et al. seems to be providing this basis.

Group boundaries amongst the Kukukuku tend to correspond to dialect boundaries, but do not seem to have any other function. The Kukukuku social unit is an agglomeration of contiguous hamlets, each hamlet consisting of six to ten houses. This association is seldom fixed because local politics tends to cause shifting allegiances.

Editor Of Pidgin Literature At Luther Press, Madang

By 1965 Freund had reached 58 years of age and the constant walking had begun to take its toll. In May of that year he decided to take up a post at the Yorketown-Minlaton Parish in South Australia. Dora's aging mother needed care and Freund thought the time had come to leave New Guinea. After 14 years at Menyamya the Freunds left for Australia. Freund was presented with 6 arrows by a leader at Kwaplalim village as a farewell gift.

While at Menyamya, even though he was flat out running the mission, Freund had sat up at night printing and binding Bible stories which he had translated into *Tok Pisin* (Pidgin English) for his evangelists to use in the villages. These first

rough booklets eventually became the standard Bible story text throughout Papua New Guinea for the Lutherans and other denominations. At one stage, whilst on furlough, he had volunteers at Gawler in South Australia roneoing and binding copies for him (Anonymous 1964). The Lutherans initially had an aversion to *Tok Pisin* and had used *Yabem*, from the people around their first station at Simbang near Finschhafen, and then *Kotte*, from the people at Sattelburg (Flierl 1937: 14). Freund, being a pragmatist, began using *Tok Pisin* on Rooke Island when he discovered it was widely used and the people had difficulty with *Yabem*. Eventually the rest of the Lutherans fell in line with him.

On the basis of this work he was recalled from Australia and returned to New Guinea on 29 May 1968 as Editor of Pidgin Literature with the Luther Press at Nagada, near Madang. Under Freund's editorship the Luther Press not only produced religious tracts but booklets on recreation and games, running a business, keeping fowls, growing vegetables, fish farming, soil care, growing rice, caring for goats and the proper care of pigs.

Retirement

Finally, in 1976 when he was 69 years old, Freund decided to retire. He and his wife visited Menyamya between 22–26 April , where Russ and Selma Weier and a Dutch nurse, Adrienne Hoogvliet, were the only European staff left. Russ took Harold and Dora out to Concordia and Kwaplalim in his Landrover for a final look around. The Freunds arrived in Cairns on their way home on 28 May 1976. After a brief holiday, Harold began a series of stints as relieving Pastor all over south-eastern Australia. In 1983, when Dora was eighty, they decided 'enough was enough' and retired again, this time for good!

Collecting The Material

In early April 1950, whilst at Yaramanda, Pastor Freund sent the South Australian Museum a wig cover, made from the cocoon of a colony of moths. Freund had been intrigued by the wig cover and thought the Museum might be interested in it. He had no real intention of supplying further material to the Museum until Tindale wrote back to him on 12 April of the same year, pointing out that the Museum Board

> has been able to find some funds so that interested observers could collect material on our behalf at cost and have them shipped to us for permanent preservation.

Pastor Freund did not ship any further material to the Museum at this stage but with Tindale's letter in mind collected a range of interesting objects. On 23 February the following year, while he was in Australia on furlough waiting for a permit to enter the Menyamya area, he visited the Museum and donated these objects, along with related ethnographic information, to Tindale for inclusion in the Museum's collections.

During the same visit Freund showed Tindale a stone club which he had collected at Menyamya in Kukukuku country during his first visit there. Freund did not donate the club to the Museum but allowed Tindale to sketch it and take notes. Tindale was very interested in the prospect of obtaining material from Menyamya because it was close to the area he had visited during the war and had read about in Beatrice Blackwood's 1939 article in the 'Geographical Journal'.

The first consignment from Pastor Freund was despatched from Menyamya on 8 July 1951 with a letter to Tindale which said,

> I decided to send you a trial package of material from our Kukukukus. Both Customs and Health Authorities keep an eagle eye on any such things entering Australia. So I am interested to hear when, in what condition, and with what difficulties you get the package.

Thus began a series of shipments which would continue for several years. As material arrived Tindale and the Museum Director, Herbert Hale, wrote back to Freund with useful information related to the identification of the materials used in the artefacts and providing copies of articles gleaned from reports and publications not available to Freund. On 26 March 1952, for instance, Tindale wrote to Freund and included information about the reeds the Menyamya people used to make mens' sporrans:

> I have just received an identification of the reed which the natives of your area use for the making of grass skirts. It has been identified for me as *Eleocharie dulcis* which grows from Brisbane north through New Guinea and the East Indies to India. The reed is widely cultivated, being used as a food root as well as medicine. I enclose an extract from a book by William Roxburgh entitled 'Plants of the Coast of Coromandel' dated 1819, which gives an account of the plant. In that book it is called *Scirpus tuberosus* but it is the same species.

Inevitably, Tindale also had specific questions

about the use and manufacture of items and Freund endeavoured to answer these in his return letters.

Freund, with a naturally inquisitive mind, not only provided these details but also sent Tindale samples of raw materials and objects in various stages of manufacture. As this process developed, the Museum slowly acquired a unique collection from a unique group of people in an area which had only just been effectively opened up to the world at large. Following Freund's departure, Tindale made contact with L. Howie, a builder working for the Catholic Mission at Wabag, and arranged to buy more Engan artefacts for the Museum.

Inspired by the material arriving at the Museum from collectors like Freund, Tindale was keen to conduct his own expedition to the Highlands and began to press the Museum Board for funds. In April 1950, he wrote to Freund requesting details of the conditions in the Wabag area.

> Would it be possible for you to inform us about general facilities for visiting the Wabag area and any possibilities for say an individual researcher to stay in the vicinity for a period of from four months to eight months at reasonable cost?

Despite his best efforts the Museum Board remained unconvinced by Tindale's arguments and declined all of his annual requests for the funding of an expedition. By 1955, obviously frustrated by his lack of success, Tindale went to the press. At the time, a series of reports had appeared in both local and interstate newspapers related to the discovery of the so-called Shangri-la Valley in the Central Highlands and Tindale again stressed the need for a Museum expedition. His subsequent entreaties to the Museum Board were again unsuccessful and he made no further requests for funding. He did, however, maintain his interest in the area and continued to correspond with collectors like Freund. He also collected copious notes and press clippings on the area right up until the late 1960s. It is interesting to speculate how the Museum's New Guinea collections would have developed if Tindale had been allowed to carry out his own collecting programs. The Museum's first expedition to New Guinea since Edgar Waite's of 1918 did not occur until 1968–9 when Graeme Pretty and Tony Crawford collected material from the Southern Highlands and the Western District.

Documenting The Collection

In 1994 I resigned from the Aboriginal Heritage Branch in Adelaide, where I had been the Registrar of Sites, and took up part time consultancy work. This change of pace has allowed me to pursue a number of personal interests. Before joining the Branch in 1974 I had been a Patrol Officer and Publications Officer in Papua New Guinea and I have maintained an interest in the area ever since. I have returned there to work on several occasions, most recently this year. In 1995 I approached the South Australian Museum with a view to assisting, on a voluntary basis, with research related to their Papua New Guinea collections. The Curator of Foreign Ethnology, Barry Craig, thought that, given my experience in particular areas of Papua New Guinea, the Freund material and related collections would be appropriate for me to work on.

Locating Pastor Freund was relatively easy. I simply looked up A. P. H. Freund in the Adelaide Telephone Directory and there he was with an address at the Lutheran Homes in Payneham. A few discrete enquiries ascertained that he was in good health and very probably interested in helping with the collection.

As it turned out Pastor Freund had been helping with the setting up of a Lutheran New Guinea Mission Museum at Hahndorf, writing copious notes for the collection, which had accumulated at the Lutheran Church offices in North Adelaide over many years. I arranged to meet him at the South Australian Museum and showed him the accession cards and copies of his photographs. He was mildly surprised to see this material because it had been over 40 years since he had donated it to the Museum and he had forgotten about it.

When we visited the Museum's off-site storage facility at Netley the following week and looked at the artefacts, many of which bore tags in his handwriting, Pastor Freund was convinced enough for us to get down to the business of inspecting each item and recording his observations and memories of it. Pastor Freund was very thorough, a trait which carried him through his years as a missionary, coastwatcher and editor. He took the transcripts of our conversations about the artefacts home with him and checked, reworked and added to them until he was satisfied that the information (and grammar and punctuation) was accurate. We reworked the final transcript, over 30 pages, several times before he was satisfied with it.

During the process of making the transcript, I endeavoured to locate as much relevant information about Engan and Kukukuku material

culture as possible. Pastor Freund incorporated information from these sources into the transcript where he thought it was appropriate or where his memory failed him. On one occasion he called in the Kleinigs, who had worked with him in New Guinea and now live in Adelaide, to verify the names and uses of some of the items. As we worked our way through the collection I photographed each item in monochrome with a scale and its relevant accession number.

The system of recording accessioned items in the Foreign Ethnology Collection at the Museum was in the throes of being updated and computerised during the time of the making of the transcript and a few items could not be easily located. On occasion I had to skim through photocopies of shelf lists hoping to spot elusive objects. When this failed Pastor Freund and I physically searched the shelves looking for the items in the most likely places. Similar items are grouped together on the shelves at Netley rather than being grouped by collector. We actually found his Menyamya arrow collection, one arrow at a time, over a period of several hours by this method. As we progressed we were able to amend incorrectly numbered items and shelf locations for the computer record. We left his arrows on one shelf in one loose bundle in case we needed to go back to them later on.

Pastor Freund was over 90 years of age and his stamina and attention to detail during the above process was, for someone a little over half his age, somewhat humbling. During the period of compiling the transcript his wife, Dora, passed away and his son Martin, also a Pastor, retired because of ill health and moved to Adelaide with his family. Despite these events we completed the transcript over a period of about 9 months, working one day a week.

Discussion

Freund did not despatch all of the material that he collected to the South Australian Museum. His correspondence with Norman Tindale tended to pursue particular lines of interest and this influenced the types of items he sent to the Museum. On 12 April 1950, for instance, Tindale provided information on the species of moth from which the wig cover, which Freund initially sent to the Museum in 1950, was made. The return correspondence from Freund provided more details on wigs and their construction and the news that he had collected more samples, as well as other related items, such as pins and decorations, which he would deliver to the Museum when the opportunity arose. While Freund was interpreting from Tindale's letters the types of items which he thought the Museum would be interested in, and duly collecting these, he was, at the same time, collecting other items which were destined for other purposes.

During furloughs in 1950–51, 1953–54, 1958–59 and 1963–64, the Freunds travelled extensively in Australia lecturing and showing slides and films of their mission work at Menyamya. One of the aims of these lectures was to raise much needed funds but, for the most part, Freund was keen to show people in Australia that the efforts of the missionaries in New Guinea were worthwhile. To assist with the process of generating interest in the mission's work, Freund also took artefact collections around to show his audiences. At the end of each furlough he disposed of these collections to friends and other interested parties, rather than store them or carry them back to New Guinea.

Between 11 November 1953 and 15 August 1954, the Freunds lectured in both Australia and New Zealand. In 1954, Harold gave one lecture in Sydney and then travelled to Queensland where he spoke at seventeen different venues (Freund 1985: 158). On 13 August, near the end of the furlough, he visited the Director of the Queensland Museum, George Mack, and donated most of his touring collection to the Queensland Museum. Mack had attended one of Freund's lectures and had expressed an interest in the collection. One of the donated items, a stone club-head, originally had a handle but Freund had separated the two components on the train up from Sydney to make it easier to carry and had left the handle in a luggage rack on the train; when he went back to find the handle it was gone!

The residue of the items which had not been given to friends or donated to the South Australian or Queensland Museums was eventually passed on to Christel Metzner and her husband, who have established the Louise Flierl New Guinea Lutheran Mission Museum at Hahndorf in South Australia. Christel added this material to a larger collection of Papua New Guinean artefacts which accumulated over many years at the Lutheran offices in North Adelaide. Pastor Freund assisted in sorting and labelling this material.

While most of the items which Freund collected at Yaramanda are held by the South Australian Museum, its Menyamya collection is essentially

part of a larger collection shared by the Queensland Museum and the New Guinea Lutheran Mission Museum. These collections, however, do not exhibit the range and variety of the Freund Kukukuku material held in the South Australian Museum. There are twenty six Freund items in the Queensland Museum, fourteen of which are chestbands, four are armbands, and three are plaited belts. The rest of the collection comprises two necklaces an 'apron', a 'mat' and a clubhead (Queensland Museum, Oceanic Anthropology Collection 1997). Apart from a few items Freund has had difficulty distinguishing which Kukukuku items in the Lutheran collection are his and which come from other collectors.

A distinguishing feature of the South Australian Museum collection is the amount of ancillary material, in the form of photographs and information, provided by Freund. There is no similar level of data accompanying the Freund collection in Queensland and the New Guinea Lutheran Mission Museum collection is accompanied by much more generalised information. Unfortunately Freund was unable to provide any further information, beyond his original captions, for the photographs.

Apart from the information recently provided by Pastor Freund, the credit for the compilation of the South Australian Museum data on the Freund collection must go to Norman Tindale. He pursued Pastor Freund for copies of photographs and elicited other information from him by letter and during their meetings when Freund delivered material to the Museum. This data is dispersed in Tindale's journals and in the South Australian Museum Anthropology Archives, but when brought together provides a surprisingly useful accompaniment to the artefact collection.

The Freund collection in the South Australian Museum contains approximately seventy items from the Laiapu Enga at Yaramanda but only twenty items from the Kukukuku at Menyamya. The rest of the collection comes from Wabag, Mount Hagen and Umboi. The Yaramanda collection contains mutiple examples of specific items, such as wig covers, but the examples of artefacts-in-preparation makes it very interesting and it stands up well against the other Museum collections from the Highlands, such as the Howie collection from near Wapenamanda and the Alpers collection from the Eastern Highlands.

Little is known about L. Howie. He was a lay worker with the Catholic Mission. In 1950 he had donated a number of 'sorcerer's charms', a comb and a dyed skirt from Orokolo, west of Kerema, to the Museum. When Tindale learned that Howie was going to Wabag he arranged for the purchase of a number of specific artefacts 'at cost' for the Museum. This collection comprises twenty nine items from Wapenamanda, not far from Yaramanda, purchased in 1951 'by arrangement' with the South Australian Museum.

The majority of the artefacts which Howie collected for the Museum closely duplicate those supplied by Freund. The Museum records provide no hint of the rationale Tindale used for this duplication He does not appear to have been trying to fill in the gaps in Freund's collection nor was he simply picking up where Freund had left off. The only distinctive item collected by Howie for which there is not a Freund equivalent is a man's wig. Given Freund's interest in wig covers it would seem logical for Tindale to have sought an Engan wig for the Museum's collection but there is no record of such a direct request in the Museum's records. Tindale was careful not to mention to either Freund or Howie that he was receiving artefacts from both of them or that he was duplicating some of their material. At the time of the collections Tindale was putting the finishing touches to the refurbishment of the Pacific Islands Gallery and he may have been seeking specific items to illustrate the themes he was developing for the individual displays, although none of the Freund or Howie material was used there. There is no doubt that there was some sort of system in Tindale's collecting activities but its exact nature now seems to be lost in time.

Although Tindale had an abiding interest in the Wabag Valley and was insistent that the artefacts should be purchased 'directly from natives', rather than through a third party, his interest was mostly 'scientific' and he did not seem to have much feeling for their intrinsic value. Tindale did not object when Howie advised him that he would have to cut all of the arrows and spears he had collected for the Museum into three convenient pieces before mailing them. Tindale later advised the Methodist missionary, Ralph Lawton, to carefully break a number of earthenware pots from Kiriwina in the Trobriand Islands into suitable sized pieces before mailing them because he knew they would probably be broken in transit anyway and controlled breakages would make for easier reassembly.

The collection donated by Dr Michael Alpers comes from the Fore people of the Eastern Highlands. Dr Alpers worked extensively in this area researching the causes of *Kuru*, the so-called

TABLE 1. Yaramanda Artefacts – Comparison With Other South Australian Museum PNG Highland Collections **1**–Freund (Yaramanda), **2**–Howie (Lai Valley)*, **3**–Alpers (Fore/Eastern Highlands).

Stone, Bone & Other Tools	**1**	**2**	**3**
Grindstone			*
Axe	*	*	*
Adze			*
Bark Beater			*
Hammerstone			*
Scraper			*
Core (for flaking) [NB., but no flakes in collections]			*
Chisel			*
Sharpening Stone			*
Needle – bone	*		*
Weapons/Hunting Gear	**1**	**2**	**3**
Spear	*	*	
Shield			*
Bow	*		*
Arrow – plain palm	*	*	*
Arrow – bamboo blade	*	*	*
Arrow – pronged		*	*
Arrow – bone tipped	*		*
Arrow – barbed	*	*	*
Trap – bird			*
Ceremonial Objects	**1**	**2**	**3**
Ochre/Paint			*
Stones – magic			*
Bow – magic			*
Arrow – magic			*
Ornaments	**1**	**2**	**3**
Wig		*	
Wig Cover	*	*	
Head Dress – feather		*	*
Hat – cassowary feather	*		
Pin – Bone	*	*	
Pin – Wood	*		
Necklaces	*		*
Armlet	*	*	
Legband	*		
Headband	*		*
Waistband			*
Nosepieces			*
Clothing	**1**	**2**	**3**
Cloak			*
Apron – Male	*	*	
Rain Mat	*	*	
Tapa Cloth	*		
Belt Plaited	*		
Skirt – Female	*	*	

TABLE 1. (cont.)

Narcotics, Musical Instruments & Toys	1	2	3
Smoking Pipe			*
Flute			*
Jews Harp	*		
Drum			*
Spinning Top			*
Ball – Banana Fibre	*		*

Household Items	1	2	3
Basket	*		
Small String Bag	*		*
Rope	*	*	
Fibre – rope making		*	
String	*		*
Large Net Bag (bilum)	*	*	*
Head Rest			*
Salt	*		
Salt Making Gear			*
Gourd – Water	*		
Bowl – wooden			*
Cup – coconut			*

+ Collected 4 miles west of Wapenamanda (Yaramanda is about the same distance east of Wapenamanda).
L. Howie provided Enga names for artefacts collected on behalf of the South Australian Museum.

'laughing disease', transmitted by the consumption of human brain tissue. The collection is very large, comprising some four hundred items. Of these, two hundred and seventeen are stone axe blades. The rest of the collection is comprised of a significant number of other stone tools, such as chisels, hammerstones and sharpening stones, and a variety of magical, household and other items, including arrows and items specifically related to *Kuru*. An analysis of these three collections highlights the effects of individual collectors' interests (see Table 1).

Doctor Alpers has expressed an intention to work on his collection for the Museum. The Howie collection, although small, also deserves attention because, like the Freund collection, it was made during the early days of contact in the Papua New Guinea Highlands and could be coupled to an historical perspective of the Catholic mission there, which differed somewhat in approach from the Lutherans.

The Museum only has one other Kukukuku collection; this was collected by Roger Teusner in 1969 and donated in 1981. Although Teusner collected his Kukukuku material from three villages near Concordia he also collected a few items elsewhere. He also acquired artefacts from people in the Barossa Valley in South Australia, where many Lutheran families with connections to Papua New Guinea live. His Kukukuku collection is representative and in good condition, possibly because some of it was specifically made for him. Teusner has provided a number of photographs and notes related to this collection which makes it a valuable addition to the Museum's collections. A cursory comparison with similar items in the Freund collection shows the influence of steel tools during the years between 1952 and 1969, with neatly cut edges on skirts and distinctive steel blade marks on wooden artefacts.

Although the provenance of individual items in Teusner's collection have now been confirmed, it initially presented a number of confusing elements. His collection of arrows, for instance, included a number of barbed heads and a type of binding different from the distinctive style of the Kukukuku. As it transpired, his arrow collection had been given the overall provenance of Menyamya but included several which he had collected elsewhere. The ascribing of Menyamya as the provenance for the whole collection was

TABLE 2. Kukukuku Material Culture – Comparison of Australian Held Collections to Pitt Rivers Museum Collection.
1–Pitt Rivers Museum (Blackwood), **2**–Queensland Museum (Freund et al), **3**–MacLeay Museum (Thompson), **4**–SA Museum (Freund, Teusner et al), **5**–Victoria Museum (Altus et al), **6**–Lutheran Museum (Freund).

Stone Tools	**1**	**2**	**3**	**4**	**5**	**6**
Grindstone	*					
Adze	*	*	*	*	*	*
Bark Beater	*		*	*	*	*
Hammerstone	*					
Scraper	*					
Flake	*					
Bone & Other Tools	**1**	**2**	**3**	**4**	**5**	**6**
Awl	*		*			
Plane	*					
Drill	*					
Weapons/Hunting Gear	**1**	**2**	**3**	**4**	**5**	**6**
Club (wood)	*	*		*		*
Shield	*					*
Bow	*		*	*	*	
Arrow – plain palm	*		*	*	*	
Arrow – bamboo blade	*	*	*	*	*	
Arrow – pronged	*		*	*	*	
Arrow – blunt	*		*		*	
Arrow – bone tipped	*					
Club (stone) – ball	*		*	*	*	*
Club (stone) – disc	*		*	*		
Club (stone) – star				*	*	*
Club (stone) – pineapple	*		*		*	
Club (stone) – diamond		*				
Ceremonial Objects	**1**	**2**	**3**	**4**	**5**	**6**
'Marita' Initiation Tray	*					
Bull-roarer	*					
Ochre/Paint	*					
Ornaments	**1**	**2**	**3**	**4**	**5**	**6**
Necklaces	*	*	*	*	*	*
Armlets	*	*	*		*	
Headbands	*					
Ear Rings	*					
Nosepieces	*		*	*		
Clothing	**1**	**2**	**3**	**4**	**5**	**6**
Cloak	*		*	*	*	*
Sporran	*	*	*	*	*	*
Bark Back Cover	*					
Baldric (Chestband)	*	*	*		*	*
Skirt	*		*	*	*	*
Belt	*	*	*	*		

TABLE 2 (cont.)

Narcotics	**1**	**2**	**3**	**4**	**5**	**6**
Pipe	*					
Lime Gourd	*					
Tobacco Dryer	*					
Musical Instruments	**1**	**2**	**3**	**4**	**5**	**6**
Flute	*					
Pan Pipe	*					
Jews Harp	*		*			
Drum	*					
Medicines	**1**	**2**	**3**	**4**	**5**	**6**
Clay	*					
Red Earth	*					
Prickers	*					
Bark	*		*			
Toys	**1**	**2**	**3**	**4**	**5**	**6**
Bark Cloth Figure	*					
Reed Toy	*					
Spinning Top	*					
Bow & Arrow	*					
Household Items	**1**	**2**	**3**	**4**	**5**	**6**
String	*					
Rope				*		
Knife	*		*			
Digging Stick			*			
Broom	*					
Spoon	*					
Pot (clay)	*					
Fire Tongs	*					
Torch	*					
Firemaking Kit	*					
Small Net Bag	*		*	*	*	
Large Net Bag (bilum)	*		*	*		
Head Rest			*			
Salt	*		*	*		
Mat		*				

Note: The above table is necessarily approximate. In some cases not enough detail is available to positively ascribe an object to a particular category. In other cases a variety of items are placed in one category despite their variations eg. necklaces. Other items described in printouts from the various institutions as Kukukuku are obviously incorrectly provenanced, barbed arrows ascribed as Kukukuku for example. It is important to be aware that the types of artefacts listed in Table 1 do not represent a complete material culture inventory of the people described as the Kukukuku. Blackwood's ethnography mentions other objects such as 'sun' and 'pronged' stone clubs, cassowary bone belts, bow wrist guards, lime spatulas, aeolian flutes and water carriers which are not represented in any of the collections surveyed.

also curious because the artefacts, in fact, came from three specific villages near Concordia, some distance to the north of Menyamya, and from an area slightly different linguistically.

Apart from this collection the Museum has only an adze, stone club, axe and package of salt from unknown parts of Kukukuku country donated by three different collectors.

There are few other Kukukuku collections held outside South Australia. A complementary, but smaller and less diverse, collection made by Owen Altus is lodged with the Museum of Victoria in Melbourne. About 150 Kukukuku items collected by Patrol Officer George Chisholm in 1913 and 1914, inland from the Gulf of Papua, were included in the Official Papuan Collection assembled by the Papuan Administrator, Hubert Murray, between 1907 and 1929. The Australian Museum took about 12% of the entire collection and the rest went, at Murray's request, to the Australian Institute of Anatomy in Canberra in 1934. In 1984 it was transferred to the National Museum of Australia. Chisholm provided only brief documentation on the tags he attached to his collection and it would be necessary to locate his original Patrol Reports to gain further information (Craig 1991: 54). The Derek Thompson collection, made chiefly at Menyamya in the 1980s and held by the Macleay Museum in Sydney (Macleay Museum 1986), is probably the most recent large Kukukuku collection. A useful summary of the various Papua New Guinea collections held in Australian institutions is provided by Bolton (1980).

Overseas, the Beatrice Blackwood collection at the Pitt Rivers Museum in Oxford (Pitt Rivers Accession Book: 36–81) is the most complete site-specific (Upper Watut) Kukukuku collection known to this writer. The collection made by Dr Carleton Gajdusek and held by the Peabody Essex Museum in Salem, Massachusetts, is extensive and is detailed in a thesis by Peter Fetchko (1972). Another significant collection is the Maurice Godelier Collection in Paris. The British Museum has a string bag, a bamboo pipe, a necklace and a shield collected at various times between 1907 and 1980 which are described as Kukukuku (British Museum Accession Book 1996). A lengthy film of the Baruya Kukukuku was made by Godelier and the Australian ethnographic film maker, Ian Dunlop, in the 1970s but is generally unavailable because of its depiction of initiation rites.

One of the consistent features of the South Australian Museum's Pacific Islands and Papua New Guinea collections, in common with other Australian museums, is the randomness of its individual collections. Since the museums could not undertake their own specific fieldwork, as Tindale wished to do in the New Guinea Highlands in the 1950s, they were subject to the whims and fancies of their various donor-collectors. Most of the collectors were men and this is possibly why there is a preponderance of weapons in the Papua New Guinea collections. All of the Australian museums have thousands upon thousands of arrows and spears from Papua New Guinea and the Pacific region.

The collection made by Beatrice Blackwood does not follow this trend however. With the exception of a few specific and more obscure items, Blackwood's collection is a considered representation of Kukukuku material culture (see Table 2). The Freund Kukukuku collection, taken in its entirety over the three repositories, makes a reasonable showing by comparison. There is no heavy emphasis on weapons and there is a considered attempt at finer detail. Freund was fascinated by the technology and skill of both the Laiapu Enga at Yaramanda and the Kukukuku at Menyamya. His notes on the manufacture of commodities like bark cloth and the details of weaving and string-making in the recently prepared transcript (1996) accompanying his South Australian Museum collection demonstrates his attention to detail. He has also provided excellent photographs and texts on items not in the collection, such as Umboi canoe-making, the development of *Tok Pisin* (Pidgin English) and the ceremonial life of both the Enga and the Kukukuku.

The problem with Freund's Kukukuku collection, of course, is the fact that it is spread over three institutions. The South Australian Museum has the bulk of the collection but there are a number of significant items lacking. The Museum does not have a Kukukuku shield, for instance, but there is one in the New Guinea Lutheran Mission collection. It would be useful to bring these collections together at some stage, but this possibility is unlikely, given the limited resources of the South Australian Museum. It would also be useful, using the Blackwood collection as a reference point, to attempt to locate samples of some of the other interesting Kukukuku artefacts lacking in the Freund collection, such as some of their stone technology, i.e. bark beaters, templates, stone flakes and chisels. These would be valuable additions to the collection and could enable a comprehensive exhibition of Kukukuku material culture to be mounted by the Museum in the future.

Chronology

1887 Freund's father Johann and his mother Anna take up land near Mt Mary, South Australia.
1907 Freund born on 6 July.
1925–6 G. F. W. Zimmer's Kukukuku photographs published in Papuan Report for that year.
1928 William McGregor encounters Enga people on the Yuat River during a patrol from the Sepik.
1931 German prospector Baum killed in Kareeba-Indiwi country together with eight of his Buang carriers.
1931 Mick and Pat Leahy attacked by Kukukuku.
1931 Pilot Trist dies in forced landing near Zenag.
1932 Clarius and Naylor, together with seven of their Buang carriers killed by Kukukuku.
1933 Patrol Officer J. K. McCarthy builds airstrip at Menyamya to service prospectors.
1933 Tommy O'Dea takes the first plane into Menyamya.
1933 No gold found and Menyamya closed.
1933 Freund graduates from Concordia College at end of year.
1934 Freund becomes Pastor at Arno Bay on Eyre Peninsula.
1934 Freund marries Dora Ey on 6 April.
1934 Michael Leahy leaves Mount Hagen on 11 June to explore the area to the west.
1934 Incident at Doi in Enga country on 25 June resulting in the killing of 15 people and the wounding of many others.
1935 Freund travels to New Guinea on Macdhui arriving Moresby in December.
1936 Freund settles at Awelkon on Rooke Island.
1936 Beatrice Blackwood starts fieldwork in the Upper Watut.
1936 The Lutheran missionaries, Lechner, Reiner and Maurer explore the country south of Wau.
1937 Blackwood finishes fieldwork in February.
1937 Patrol Officer Downs goes to Kobakini to set up base camp and is constantly harassed by Kukukuku.
1938 The Hagen-Sepik Patrol under the charge of James Taylor leaves Mount Hagen to explore the country to the Dutch border on 9 March.
1938 Martin Freund born in May in Gawler, South Australia.
1938 Taylor constructs a base camp and landing ground at Wabag during July.
1938 First plane lands at Wabag on 8 August.
1939 Taylor leaves Wabag on 7 June for Mount Hagen, arriving on 18 June.
1939 Roland Freund born on16 June at Finschhafen.
1940 Freund recruited as a coastwatcher by Eric Feldt.
1941 Dora and sons evacuated to Australia.
1942 Freund and other Lutherans join the New Guinea Volunteer Rifles at Lae.
1942 Wabag becomes a permanent Patrol Post.
1943 New airstrip built at Wabag.
1943 Freund discharged from Army in Australia in July.
1943 Tindale flies from Australia to Lower Watut to inspect downed Japanese planes. Obtains copy of Blackwood's article on the Kukukuku.
1946 Freund returns to Umboi (Rooke Island) and spends 18 months getting the mission back into shape.
1947 Ian Downs attacked by Siminapa Kukukuku on the upper Banir.
1947 Ogelbeng the most western Lutheran Mission.
1947 Seventh Day Adventists set up mission at Rakamanda near Wabag on 4 June.
1948 Catholics set up mission at Pompabus near Wabag in October.
1948 Freund and Kleinig set out from Ogelbeng on 23 August for Wabag Valley.
1948 Freund arrives at Yaramanda on 26 August.
1950 Freund leaves Yaramanda on 22 June.
1950 Decision made to reopen Menyamya.
1950 Hurrell leaves Slate Creek for Menyamya on 31 October.
1950 Hurrell and Keenan arrive on 9 November and clear old airstrip.
1950 Tindale gets funds from the Museum Board to purchase New Guinea artefacts.
1951 Freund visits Tindale on 24 February between leaving Yaramanda and going to Menyamya. Brings Enga material to donate to the Museum.
1951 Freund sends Tindale a 'trial' package of artefacts from Menyamya which arrives on 8 July.
1951 Freund arrives at Menyamya.
1952 Freund brings cattle into Menyamya on 25 November.
1952 Tindale selects photos from Freund's touring set and makes copies for Museum. Sends copies to Freund for annotation.
1954 First calves born at Menyamya.
1955 Deaconess Merna Thamm arrives at Menyamya to work with women.
1962 Concordia station established by mission 6 miles north of Menyamya. Missionaries build road to it.
1964 Freund moves out to Concordia on 16 June after the Jordans leave for Australia.
1965 Freund leaves Menyamya for Yorketown, South Australia.
1965 Last of the Kukukuku brought under Administration control.
1968 Freund returns to PNG to take up job as Editor of Luther Press at Nagada near Madang.
1976 Freund visits Menyamya on April 22–26. Only three European staff there.
1976 Freund leaves PNG and arrives in Cairns, Queensland on 28 May.

Figure 1. Salt manufacture at Menyamya. Bushes from the plant which produces 'Job's Tears' seeds are burnt and the ashes dissolved in water which is then filtered through fern leaves (mounted on a frame) into a bamboo pipe for drying in the sun or by a fire. Similar methods were observed by Freund at Yaramanda, although in the Mount Hagen area reeds soaked in saline pools were burnt (Photo by A. P. H. Freund – SAM Archives AP808).

Figure 2. A man from Yaramanda with a large bundle of salt wrapped in leaves (Photo A. P. H. Freund – SAM Archives AP670).

Figure 3. A small bundle of salt from Yaramanda collected by Freund for the South Australian Museum (Accession number A42379 – photo by P. Fitzpatrick).

Figure 4. A well-loaded woman at Yaramanda about 1949 with net bags full of sweet potato for sale. The woman also has a beaten bark cloak for protection from the sun and rain. The bark cloth covering her right breast has been soaked in fluids from the body of her dead husband and is being carried as part of the mourning process (Photo by A. P. H. Freund – SAM Archives AP778).

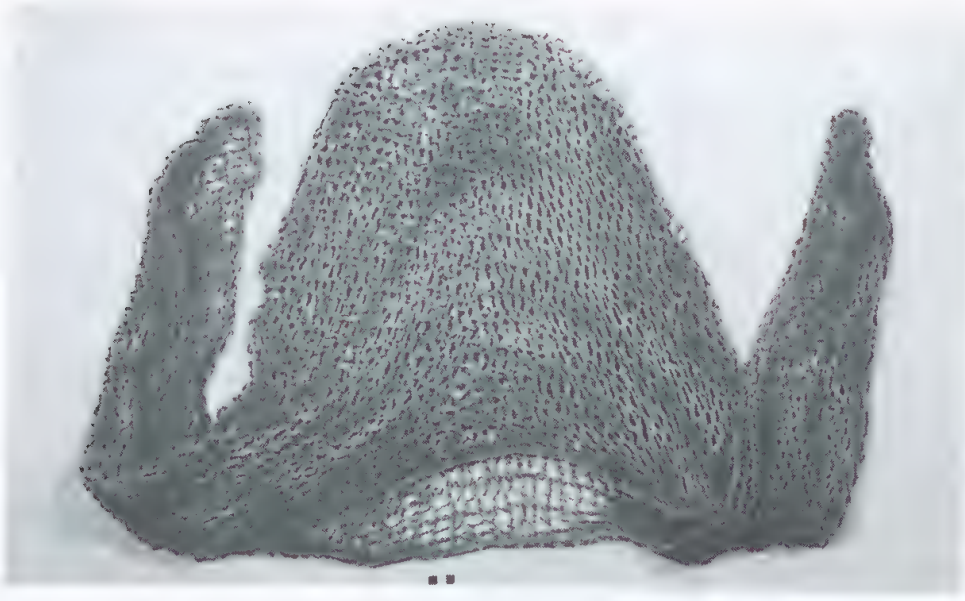


Figure 5. A net bag similar to the one shown in Figure 4 donated by Freund to the South Australian Museum (Accession number A42341– photo by P. Fitzpatrick).

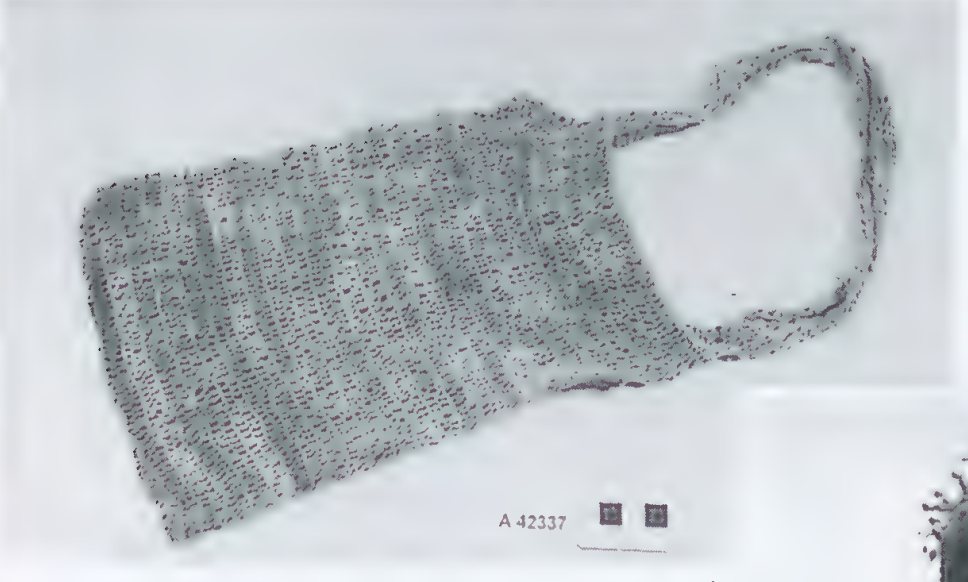


Figure 6. A man's net bag from Yaramanda. The use of such bags was almost universal in Papua New Guinea and the custom persists in many areas today. Kukukuku men carried similar bags (Accession number A42337 – photo by P. Fitzpatrick).

Figure 7. A Kukukuku man called Itamebiakavo from Kabag, about 9 kilometres east of Menyamya. He is wearing a bandolier made of bark fibre interwoven with yellow orchid stems. The bandoliers were often also worn as belts. Itamebiakaro was blinded in one eye by an arrow. The other decoration around his chest is a bandolier of cowrie shells (Photo A. P. H. Freund – SAM Archives AP769).

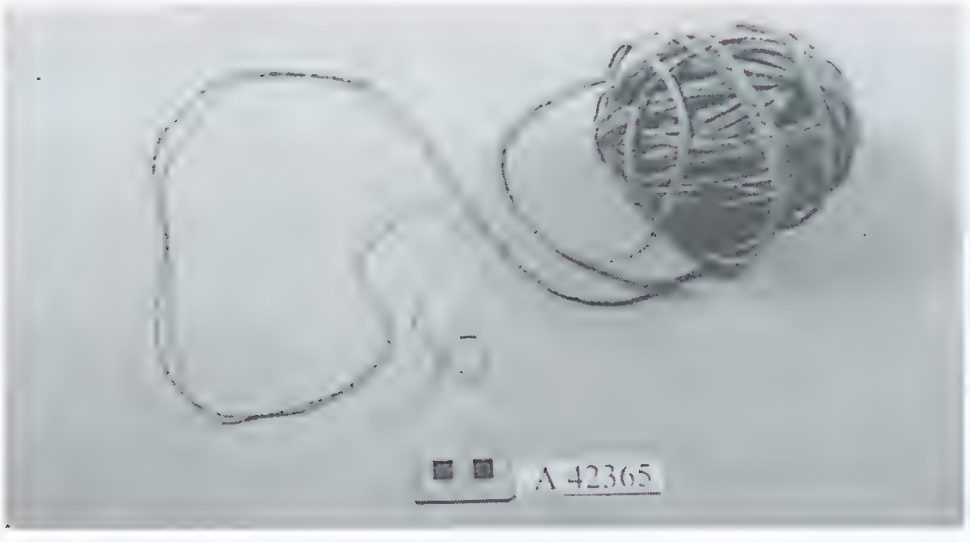


Figure 8. A sample of the type of bandolier shown in Figure 7 donated by Freund to the South Australian Museum. This bandolier measures over 30 metres in length (Accession number A42365 – photo by P. Fitzpatrick).

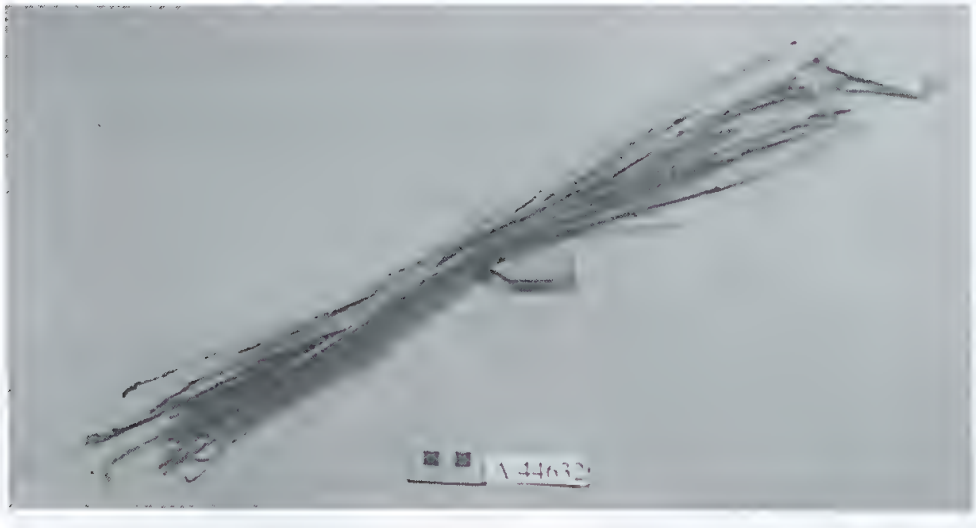


Figure 9. A sample of the type of orchid stems collected for interweaving into bandoliers like the one shown in Figure 7. This sample was collected by Freund specifically to accompany the bandolier shown in Figure 8 (Accession number A44632 – photo P. Fitzpatrick).

Figure 10. A typical Kukukuku 'sporran' or man's grass apron. Additional layers are added to create the bulging effect of the 'sporran'. The man is also wearing a fibre and orchid stem belt above his 'sporran'. The cassowary bones about his waist indicates that he is married and has at least one child. These bones were mistakenly described as human bones by early writers (Photo by A. P. H. Freund – SAM Archives AP799).

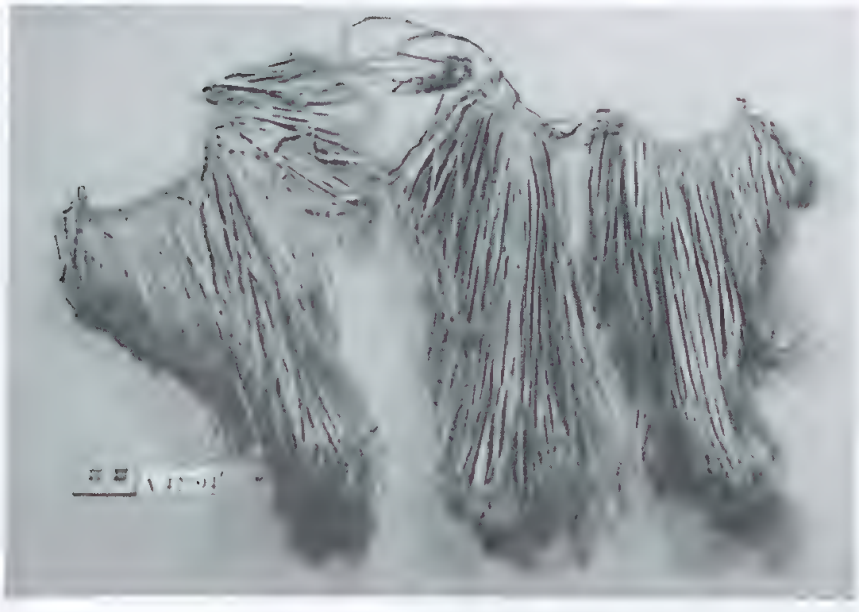


Figure 11. A sample of a Kukukuku man's grass apron or 'sporran' (as in Figure 10) donated by Freund to the South Australian Museum (Accession number A42794 – photo by P. Fitzpatrick).

Figure 12. A young woman from Yaramanda wearing necklaces of cowrie shells. These shells were used by the missionaries and government officers as currency but as more and more were brought into the area their value diminished (Photo by A. P. H. Freund – SAM Archives AP622).

Figure 13. A sample of the type of necklace shown in Figure 12 donated to the South Australian Museum by Freund. (Accession number A42358 – photo by P. Fitzpatrick).

Figure 14. A Kukukuku man called Tandatagagakata from Wiama village about 8 kilometres south of Menyamya. He is wearing a bark cape which is fastened by a drawstring to a tuft of hair deliberately left for the purpose on an otherwise shaved head (Photo by A. P. H. Freund – SAM Archives AP768).

Figure 16. Two men from the Mount Hagen area wearing beaten bark wig covers (Photo by A. P. H. Freund – SAM Archives AP631).

Figure 15. A stone beater used to make bark cloth. The bark attached to a Mulberry branch is beaten on a larger log and the crushed fibre sheet peeled off. This beater was collected by R. Teusner (Accession number A67591 – photo P. Fitzpatrick).

Figure 17. A sample of bark cloth used as a wig cover, collected by Freund at Yaramanada (Accession number A42343 – photo P. Fitzpatrick).

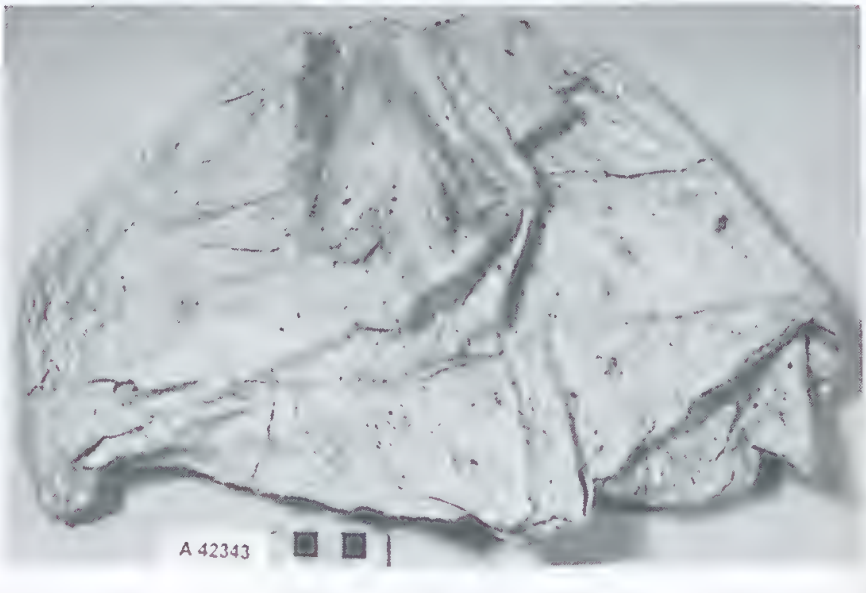


Figure 18. The method used to manufacture wig covers. Unlike the manufacture of bark cloaks, a small piece of Mulberry branch is used and the beater is of wood, rather than stone. A finer texture is achieved by beating the bark as thin as possible. The roughly cylindrical shape is drawn together at one end by string (Photo by A. P. H. Freund – SAM Archives AP662).

Figure 19. A man from Yaramanda dressed for his wedding ceremony. He is wearing an elaborate wig under a woven cover similar to the one shown in Figure 20. He is also wearing a large 'Baler' shell around his neck, bone pins in his wig, elaborate armbands and a specially woven fibre apron (Photo by A. P. H. Freund – SAM Archives AP634).

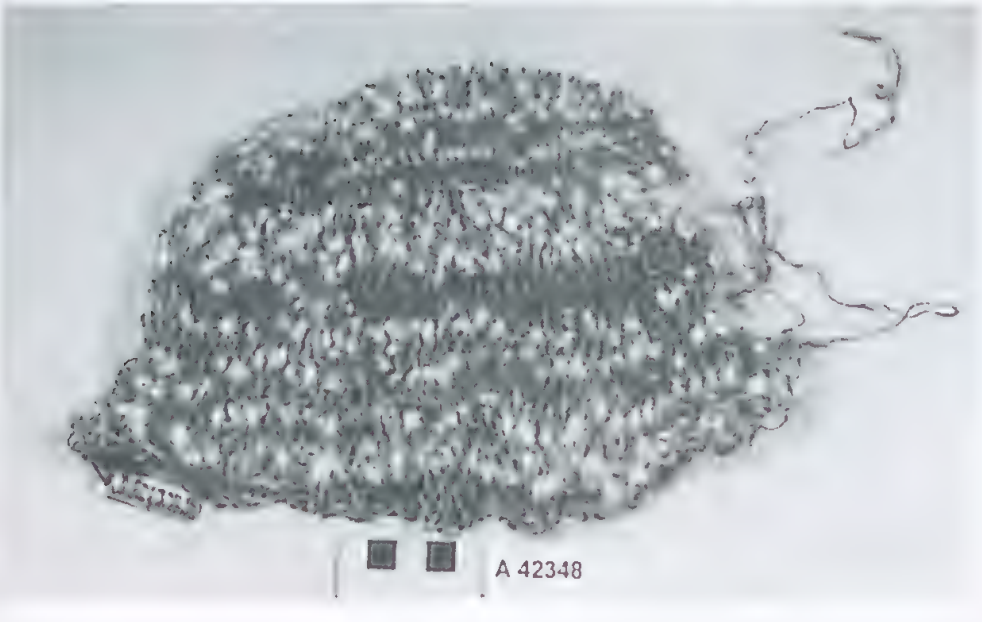


Figure 20. This type of wig cover is designed to be more decorative than protective and is generally worn during ceremonies such as the wedding for which the man in Figure 19 is dressed (Accession number A42348 – photo by P. Fitzpatrick).

Figure 21. A large gathering of people and pigs at Yaramanda for a pig exchange or Te'e ceremony (Photo by A. P. H. Freund – SAM Archives AP653).

Figure 22. A sample of the special rope used during pig exchange ceremonies to fasten a pig by one leg to a stake. These ropes and stakes were part of an elaborate tallying system for the exchanges. This example collected by Freund is unused and was probably made especially for him to send to the South Australian Museum (Accession number A42338 – photo by P. Fitzpatrick).

Figure 24. Young woman at Yaramanda during the early stage of the establishment of the Lutheran Mission there. (Photo A. P. H. Freund – SAM Archives AP621).

Figure 23. Men's apron decorated with pigs' tails. Collected by Freund at Yaramanda (Accession number A42353 – photo by P. Fitzpatrick).

Figure 25. Mother and child at Yaramanda (Photo A. P. H. Freund – SAM Archives AP616).

Figure 26. Some of the earlier Yaramanda Mission buildings overlooking the Lai River in 1948 (Photo by A. P. H. Freund – SAM Archives AP664).

Figure 27. The Dragon Rapide which brought the school teacher, Owen Altus, to Menyamya in 1951. He is standing with Pastor Horrolt and the pilot (Photo by A. P. H. Freund – SAM Archives AP815).

Figure 28. Pastor Freund with a group of Kukukuku men during the early establishment of the Lutheran Mission at Menyamya. (Photo A. P. H. Freund – SAM Archives AP805).

Figures 29. Typical early Kukukuku visitor to the missionary camp in 1952. Few women came on these early visits (Photos by A. P. H. Freund – SAM Archives AP798).

Figure 30. The Menyamya Mission school teacher, Owen Altus, with a Kukukuku man. Altus is 1.84 metres tall. (Photo by A. P. H. Freund – SAM Archives AP766).

Figure 31. Pastor Scherle buying food at the camp boundary during an early exploratory trip a few kilometres out of Menyamya in 1952 (Photo by A. P. H. Freund – SAM Archives AP785).

Figure 32. A. P. H. Freund and the author editing notes on the collection at the South Australian Museum in 1996. (Photo by A. P. H. Freund).

Acknowledgments

Apart from Pastor Freund a number of other individuals offered invaluable assistance during the process of researching the collection. Owen Altus and Reverend and Mrs Kleinig, retired Lutheran missionaries, come to mind, as does Doug Young from the Catholic Diocese of Wabag. Barry Craig, from the South Australian Museum, facilitated access to the collection and offered much needed technical and editorial advice. Kate Alport assisted with my various forays into the South Australian Museum archives. The curators of various museums and institutions holding Kukukuku and Enga material in Australia and overseas provided valuable data, especially Mike Quinnell from the Queensland Museum. Lloyd Hurrell graciously replied to my written enquiries, as did Doug Parrish of the Retired Officer's Association of Papua New Guinea. Mike O'Hanlon and Jim Specht read the draft and offered much valued professional advice.

References

ANONYMOUS. 1931. Where Life Still Offers Adventure: New Guinea; and Its Murderous Cannibals. *Illustrated London News* 363. 5 September.

ANONYMOUS. 1964. Lutherans in Gawler Aid N.G. Mission Work. *The Bunyip*, 9 January. Gawler, South Australia.

BLACK, J. R. & BRIDGE, K. W. T. 1934. *Patrol Report Number 23 of 1933/34.* Salamaua. Morobe District, Mandated Territory of New Guinea.

BLACKWOOD, B. 1939. Life of the Upper Watut, New Guinea. *Geographical Journal* 94(1): 11–28.

BOLTON, L.M. 1980. 'Oceanic Cultural Property in Australia: A Pilot Survey of Major Public Collections. Australian National Commission for UNESCO: Sydney.'

BRENNAN, P.W. 1970. 'Exploring Enga Culture: Studies in Missionary Anthropology.' Kristen Press: Wapenamanda.

BRITISH MUSEUM ACCESSION BOOK. 1907:159; 1919:112; October 1980, items 4–7.

BROWN, P. 1978. 'Highland Peoples of New Guinea.' Cambridge University Press: Cambridge.

BURTON, J. 1996. The Upper Watut. *What Tribe is That – Papua New Guinea.* http://burton.anu.edu.au/SpecialProj/PNG/MOR/UpperWatut/UpperWatut.html.

CONNOLLY, R. & ANDERSON, R. 1987. 'First Contact.' Viking: New York.

CRAGGS, E. M., KOOPTZOFF, O. & WALSH, R. J. 1958. Blood Groups of the Kukukuku. *Oceania* 29: 67–70.

CRAIG, B. 1991. 'Report of Consultancy: Documentation of Melanesian Collections in the National Museum of Australia.' National Museum of Australia: Canberra (unpublished).

DOWNS, I. 1980. 'The Australian Trusteeship, Papua New Guinea 1945–75.' Australian Government Publishing Service: Canberra.

DOWNS, I. 1986. 'The Last Mountain: A Life in Papua New Guinea.' University of Queensland Press: St. Lucia.

FETCHKO, P. 1972. 'Anga Material Culture.' Masters Thesis, presented at George Washington University, Washington DC.

FISCHER, H. 1959. Ethnographica von der Kukukuku (Ost Neuguinea). *Baessler-Archiv (Neue Folge)* 7: 99–122.

FISCHER, H. 1961. Spiele der Wotut (Ost-Neuguinea). *Veröffentlichungen des Museums für Völkerkunde zu Leipzig* 11: 141–152.

FISCHER, H. 1963. 'Watut: Notizen zur Kultur eines Melanester-Stammes in Nordost-Neuguinea.' Braunschweig.

FISHER, N. H. 1936. Amongst the Kukukuku. *Walkabout* No.7. May.10–11.

FLIERL, J. 1937. 'Unter Dem Kreuze.' Auricht's Printing Office: Tanunda.

FRERICHS, A. C. 1957. 'Anutu Conquers in New Guinea.' The Wartburg Press: Columbus, Ohio.

FREUND, A. P. H. 1989. 'Missionary Turns Spy: Pastor APH Freund's Story of His Service with the New Guinea Coast Watchers in the War Against Japan 1942–43.' Lutheran Homes Incorporated: Adelaide.

FREUND, A. P. H. 1996. 'Notes on the Freund Collection held by the South Australian Museum.' South Australian Museum: Adelaide. (Unpublished MS).

FREUND, D. 1985. 'I Will Uphold You: The Memoirs of Dorothea M. Freund, Nee Ey.' A. P. H. Freund: Adelaide.

FREUND, R. P. 1969. 'Western Innovations and Laiapu Enga Values.' ANZAAS 41st Congress, Adelaide, 18–22 August. New Guinea Lutheran Mission – Missouri Synod.

HALLPIKE, C. R. (ed.) 1978. 'The Kukukuku of the Upper Watut', by Beatrice Blackwood. Pitt Rivers Museum: Oxford.

GODELIER, M. 1969. La monnaie de sel des Baruya de Nouvelle-Guinée. L'Homme. *Revue Française d'Anthropologie* 9(2): 5–37.

GODELIER, M. 1971. Le visible et l'invisible chez les Baruya de Nouvelle-Guinée. Pp.263–269. *in*: J.M.C.

Thomas and L. Bernot (eds). *Langues et Techniques, Nature et Société. II. Approche Ethnologique, Approche Naturaliste.* Editions Klincksiek.

GODELIER, M. 1986. 'The Making of Great Men: Male Domination and Power among the New Guinea Baruya.' Cambridge University press: Cambridge.

HIDES, J. G. 1936a. 'Papuan Wonderland.' Blackie & Son: London.

HIDES, J. G. 1936b. 'Savage Patrol.' National Travel Club: New York.

HUMPHRIES, W. R. 1923. 'Patrolling in Papua.' Fisher & Unwin: London.

HURRELL, A. L. 1996. Letter to author dated 22 October 1996.

HURRELL, W. R. 1951. *Patrol Report Number 2 of 1950/51.* Menyamya, Morobe District, Territory of Papua New Guinea.

IDRIESS, I. L. 1933. 'Gold Dust and Ashes.' Angus & Robertson: Sydney.

JONES, P. G. 1993. A Brief Survey of the South Australian Museum's Pacific Collections. *Pacific Arts* No.7, January.

JONES, P. G. 1994. Obituary, Norman B. Tindale, 12 October 1900 – 19 November 1993. *Records of the South Australian Museum* 28(2): 159–176.

KEENAN, G. R. 1952. *Patrol Report Number 1 of 1951/52.* Menyamya, Morobe District, Territory of Papua New Guinea.

KOPAMU, S. J. 1994. 'A Family Album of the Enga Adventist Jubilee 1944–1994, Dundee.' Winter and Son: Scotland.

KRUCZEK, Z. Z. 1995. 'A Decade of Struggles: The First Ten Years of Wabag Diocese in Enga Province (1982–1992).' Catholic Diocese of Wabag, Papua New Guinea.

KYAKAS, A. & WIESSNER, P. 1992. 'From Inside the Women's House: Enga Women's Lives and Traditions.' Robert Brown: Buranda, Queensland.

LAWRENCE, P. & MEGGIT, M. J. 1965. 'Gods, Ghosts and Men in Melanesia.' Oxford University Press: Melbourne.

LLOYD, R. G. 1973. The Angan Language Family, in FRANKLIN, K. *The Linguistic Situation in the Gulf District and Adjacent Areas, Papua New Guinea.* Pacific Linguistics Series C – No 26. The Australian National University: Canberra.

MACLEAY MUSEUM, UNIVERSITY OF SYDNEY. Accessions List. Thompson Collection. 86.4.1–18.

McCARTHY, J. K. 1933. *Patrol Report Number B19 of 1932/33.* Salamaua, Morobe District, Mandated Territory of New Guinea.

McCARTHY, J. K. 1934. *Patrol Report Number 15 of 1933/34.* Salamaua, Morobe District, Mandated Territory of New Guinea.

McCARTHY, J. K. 1963. 'Patrol Into Yesterday: My New Guinea Years.' Cheshire Publishing: Melbourne.

PITT RIVERS MUSEUM ACCESSION BOOK. pp 36–81 (Blackwood Collection). Oxford.

QUEENSLAND MUSEUM. OCEANIC ANTHROPOLOGY COLLECTION. Nos 9866, 6456–69 (includes Freund Collection 6460–69), 10993–4, 12495–96.

SILLITOE, P. 1988. 'Made in New Guinea: Technology in the Highlands of Papua New Guinea.' British Museum Publications: London.

SIMPSON, C. 1962. 'Plumes and Arrows: Inside New Guinea.' Angus & Robertson: Sydney.

SINCLAIR, J. P. 1966. 'Behind The Ranges: Patrolling in New Guinea.' Melbourne University Press: Melbourne.

SINCLAIR, J. P. 1981. 'Kiap: Australia's Patrol Officers in Papua New Guinea.' Pacific Publications: Sydney.

TAYLOR, J. 1938–39. *Hagen-Sepik Patrol: 1938–39.* Mount Hagen, Western Highlands District, Mandated Territory of New Guinea.

TERRITORY OF PAPUA Annual Report for 1925–26.

TINDALE, N. B. 1943. 'Journal of Sojourn in Markham Valley New Guinea Aug – Sept 1943.' (Unpublished MS). South Australian Museum Archives: Adelaide.

TINDALE, N. 1964. 'Ethnological Notes From New Guinea & Pacific Islands 1934–1964, with index.' (Unpublished MS). South Australian Museum Archives: Adelaide.

WAGNER, H. & REINER, H. 1986. 'The Lutheran Church in Papua New Guinea: The First Hundred Years, 1886 – 1986.' Lutheran Press: Adelaide.

WEST, F. 1968. 'Hubert Murray, The Australian Pro-Consul.' Oxford University Press: Melbourne.

ZIMMER, G. F. W. 1969. When the Kukukukus came from the Hills, it was to Kill. *Pacific Islands Monthly,* November, pp.85–93.

THE USHER PHOTOGRAPHIC COLLECTION FROM THE SOUTH-WEST PACIFIC

GRAHAME R. PIKE AND BARRY CRAIG

PIKE, G. R. & CRAIG, B. 1999. The Usher Photographic Collection from the South-West Pacific. *Records of the South Australian Museum* **31**(2): 215–253.

A collection of photographs was donated to the South Australian Museum in 1972. This collection includes around 630 photographs taken by Ernest Sterne Usher in Papua, New Guinea and the Solomon Islands. This paper reports research by the authors into the circumstances which gave rise to this collection and provides a brief description of the historical and cultural context of a selection of the images, with reference to some relevant ethnographic material in the Museum's collections.

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Introduction

In 1995, Barry Craig, then acting Head of the Division of Anthropology at the South Australian Museum, was looking through cupboards at the Museum's Netley storage facility. Inside one he found a box containing photographs and nitrate negatives taken in Papua, New Guinea and the Solomon Islands. He took them back to his office in the Museum on North Terrace for a closer look. On further inspection it was discovered that the collection contained some remarkably clear images of considerable ethnographic interest.

The majority of the photographs (around 630) are the work of Ernest Sterne Usher, from 1914 to 1916 a Surveyor and assistant-Geologist with an oil exploration team in the Papuan Gulf region. Some of the images are similar to those which were taken by Frank Hurley in the same region five years later (Specht & Fields 1984).[1] A further 83 prints appear to derive from photographs taken in Papua by Evan R. Stanley, Papuan Government Geologist, and 24 prints of photographs taken in Australia by Leonard Langdale Wrathall, both of whom were members of the oil exploration team.

Also included in the Usher Collection are 33 postcards of Milne Bay and Trobriand Islands produced by W. H. Cooper of the Royal Arcade, Melbourne, twelve others of Papua printed in England for the Papuan Times Ltd, and 52 of the Solomon Islands produced by the Tasmanian photographer John Watt Beattie.

In November 1995, the authors began research on the Usher photographic collection,[2] a task that was particularly difficult as the only information accompanying the collection was Usher's brief description of each of the images and a copy of a letter dated June 1972 from the donor, Usher's sister, Mrs Edith Saxton of Melbourne.

Family History

Ernest Sterne Usher was born in 1887 at Fitzroy in Melbourne. His father was Frank Usher, his mother's maiden name was Mary Margaret Apps.

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[1] Other early collections of photographs taken in the eastern Gulf region are those by A. B. Lewis in 1912 whilst collecting for Field Museum of Natural History in Chicago; E. W. P. Chinnery in 1916, a Papuan Government Resident Magistrate in the area, whose photographs are held by his daughters in Melbourne; Paul Wirz in 1930, who carried out anthropological research in the region, whose photographs are held by the Museum für Völkerkunde in Basel, Switzerland; F. E. Williams, Government Anthropologist for Papua, during his fieldwork in the Purari region in 1922 and at Orokolo in 1931–2, whose photographs are held by the Australian Archives, Canberra, and by the South Australian Museum (see footnote 6).

[2] Grahame Pike began by developing a computer index of the photographs as a recipient of funding from the Commonwealth Rehabilitation Service. He continued with indexing, the location of relatives of Usher and the search for relevant documentation as a recipient of a research fellowship from the Friends of the South Australian Museum and continues the project currently as a volunteer researcher. Barry Craig, as Curator of Foreign Ethnology at the South Australian Museum, supervised Pike's research and provided additional text for this paper based on various ethnographic sources.

Family stories have Frank Usher and his brother Arthur travelling to Australia in 1879 as crew members aboard a cable-laying ship. Frank and Arthur did not sign on for the return trip when the ship eventually docked in Melbourne. Edith Saxton, one of Frank's daughters, thought that her father initially obtained work at Melbourne's Yorrick Club, although she was not sure of the position he held.

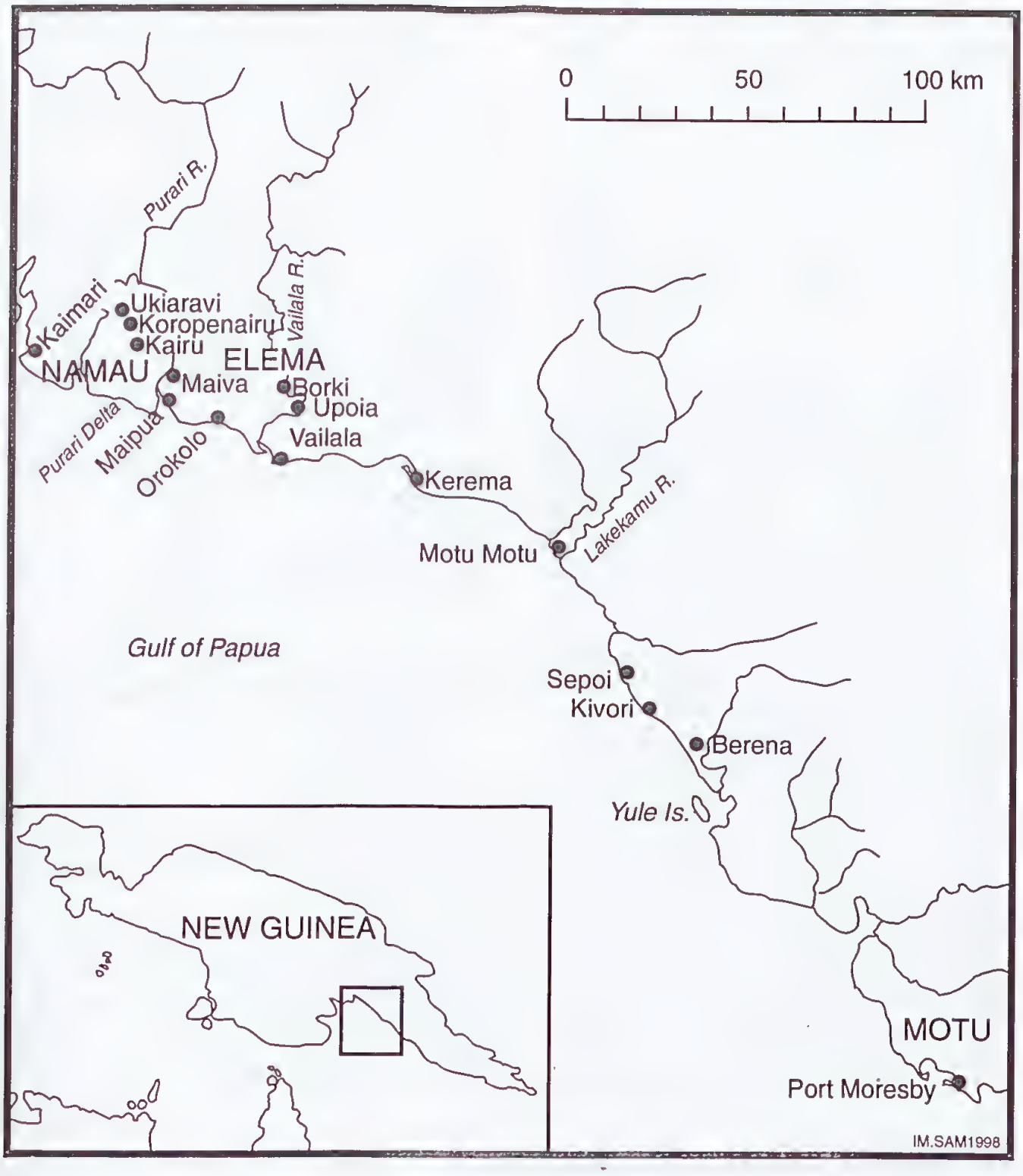
The earliest reference to Frank Usher is in the 1886 'Sands and McDougal Directory for Victoria', where he is shown to be living at 73 Moor Street, Fitzroy. He had married Mary Margaret Apps in 1881 when he was 20 years old. Frank and his wife moved into Moor Street and two sons were born; during the time they lived in Fitzroy a further four children, all girls, were born. Frank was taken into his father-in-law's business W. G. Apps Funerals, Moor Street, Fitzroy, eventually becoming a director. Frank Usher died at the age of 76 in June 1940.

Ernest attended school in Fitzroy and was, with his family, a regular at the local Parish Church of Saint Mark, George Street, Fitzroy. He took diplomas at the Working Men's College (precursor to the Royal Melbourne Institute of Technology) as a Municipal Engineer and Geologist. His first appointment was as Surveyor to the Water Supply Department. In 1908 he was Assistant Field Geologist in the Mines Department and in 1912 was stationed in Bendigo. While he was in Bendigo he attached himself to the Church of All Saints and acted on the Vestry, in the Sunday School, and as Scout Master. In 1913 he was chosen to join Dr Arthur Wade's oil exploration expedition to Papua; his loss to All Saints was greatly felt. He arrived on the Papuan field in January 1914. Following is an extract from Wade's 'Report on Petroleum in Papua' (1915: 5):

> At the request of the Government of the Commonwealth of Australia I, and my assistant, Mr L. L. Wrathall, B.Sc., A.R.S.M., left England in September, 1913, in order to investigate the geological features of the oil-bearing areas in Papua, and to report any conclusions to which I might arrive as to the methods of development which, in my opinion, should be adopted on these areas.
>
> We arrived in Port Moresby on the 15th October, 1913, and on the 17th proceeded to the Vailala River, where some work had already commenced. On the 19th October we arrived at Upoia, some 25 miles from the mouth of the Vailala River, where we were joined by Mr E. R. Stanley, the Government Geologist to the Territory of Papua, who had been instructed to assist us in the geological work. At Upoia we found that two shallow bores had been drilled by means of small hand boring plant by Mr Grebin, and abandoned for some time, whilst on the other side of the river at Orevi we found Mr Locke engaged in drilling with a larger and more efficient plant. We therefore decided to first examine thoroughly the geology of these two areas and then, with the knowledge so gained as a basis, to proceed westward towards the Purari River and endeavour to lay down some general structural lines, or at any rate to map any anticlinal features and to investigate any occurrence of natural gas and petroleum which may accompany such features. This being accomplished we were to return to the Vailala, and to work eastwards to Port Moresby with the same objects in view. We decided to map in detail all areas in which evidence of petroleum occurred on the scale of 12 inches to the mile. Later we found that so little was known of the districts through which we were travelling, and that the maps already published were so inexact, that it was necessary to fix our positions accurately by theodolite work, where possible, and to make an accurate traverse of the coast by theodolite and chain or stadia, so that the areas mapped could be placed in their proper positions with regard to the coast line. The arrival of two surveyors, Mr E. S. Usher, in January, and Mr J. W. Murray, in March 1914, assisted us greatly in this work.

Thus Usher and Murray were to assist first in the survey west along the coast from the Vailala through to the delta of the Purari River, and then along the Papuan coastline east of the Vailala as far as Port Moresby (refer Map P.217). Finally they would return for further work in the Vailala-Purari area. The photographs more-or-less follow that sequence with a date of August 1914 for their time in Port Moresby, coinciding with a visit there by the Admiral of the Royal Australian Fleet at the outbreak of the First World War. Back in the Purari-Vailala area, there is a 'Christmas 1915' date for a Purari expedition.

Perhaps early in 1916, Usher went on leave to Melbourne, sailing on board the 'Meklong'. From the sequence of the photographs, it appears that the Meklong called in at Samarai, then Herbertshoe and Rabaul, then sailed around the north and west of New Britain to Witu or Vitu (French Islands), and then south to Morobe on the southern shores of the Huon Gulf, then north-east to Ablingi and Lindenhafen on the south coast of New Britain, and finally due east to the Shortland Islands, Vella Lavella, Simbo Island, Gizo Island, Russell Island, Gela (=Nggela or Florida Islands), Tulagi Harbour and Guadalcanal in the Solomons. Presumably the ship then sailed directly to Brisbane and/or Sydney.



Map showing location of Vailala V-Purari area of the eastern Gulf of Papua.

Usher's Photographs

On his arrival at Upoia, Usher immediately began his photographic record. He preserved on film the living conditions, the characters, events and a view of native life that has since disappeared. **Album A** is a record from January to August 1914. He would have arrived by boat at the Upoia landing (**A8**) and been shown his quarters, and then taken on a tour of the camp.

The next morning he would have witnessed the general muster of the native workers and the inspection of the native police (**A7**). In his first days he took pictures of the main camp, native quarters, white quarters (**A5**) and of the terrain surrounding the camp site. In his Report, Wade describes Upoia (1915: 8):

> Upoia is situated in a basin-like depression surrounded on three sides by hills. To the north the hills rise in a precipitous escarpment to a height of 500 feet above sea-level. These hills curve round to the west, where they terminate abruptly in sago swamp. The Southern Hills are about half as high as those mentioned, while on the eastern boundary is the Vailala River, which here runs almost due south.

Towards the end of January 1914, Usher went from Upoia to Aro-Aro. He took a photograph of the departure (**A11**). Although the distance between Upoia and Aro-Aro is not great, the photograph shows a party of carriers in excess of 20, and a small contingent of native Police. They had to carry all their supplies for the duration of their stay, and for any exploratory side trips.

The camps set up by the survey teams were usually on the fringes of, or close by, an existing village. The advantage of this practice was that Usher was able to record not only camp life, but indigenous village life and, in particular, the fascinating architecture. A men's house (*eravo*) at Parimamu village in the Vailala district (**A16**) is shown near completion; Usher's note on the back of the print explains that the completed building will extend to the front posts. Another photograph (**B88**) of an almost-completed *eravo*[3] at Vailala village shows three long and narrow, carved and painted boards hanging from the scaffolding at the front. Five similar objects were described as 'dancing shields' in an illustrated sale catalogue (No.3 of October 1895, Items 6–10) of W. D. Webster, Bicester, England. They are too long and narrow to be the sacred, named *hohao* boards normally kept in the *eravo* but could be examples of the purely decorative, unnamed boards mentioned by Newton (1961: 25) or the larger, softwood non-functional 'bullroarers' cited by Mamiya and Sumnik (1982: 12) from Williams (1936: 15; 1940: 158).

Orokolo, a coastal village situated halfway between the Vailala and Purari Rivers, was the site of a London Missionary Society station and the location of the wreck of the Burns Philp ketch 'Gira' (**A19**). Sir Douglas Mawson's father, Robert Mawson, tried for several years to set up a trading and plantation business at Orokolo before he was forced by ill health to leave in 1911. In 1955, Sir Douglas Mawson presented to the South Australian Museum three bows and 75 arrows collected by his father in the Orokolo area and two pots from the Kemp Welch River area (Hood Bay, along the coast about 100 kms south-east of Port Moresby).[4]

Orokolo was a large village and being situated on the coast was one of the ports of call for the *hiri* trading canoes from the Moresby area:

> Every year, at the end of September, or the beginning of October, the season of the south-east trade being then near its close, a fleet of large sailing canoes leaves Port Moresby and the neighbouring villages of the Motu tribe on a voyage to the deltas of the rivers of the Papuan Gulf (Barton in Seligmann 1910: 96).

The *lakatoi* (trading canoes) of the Motu would carry pots and shell wealth in exchange for sago and canoe-hulls from the tribes of the Vailala and Purari regions.

The terrain was easier on the geologists and surveyors near the coast than it was inland, although the sago swamps had their characteristic difficulties. In a testimonial that Arthur Wade wrote for Usher (dated 16 August 1914 at Port Moresby) he alludes to the type of country his surveyor had to cope with:

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[3] The men's houses among the Elema speakers, living along the coast between Orokolo to the west, through the Vailala River area as far as Sepoi (near Cape Possession) to the east, are called *eravo*. The Namau speakers of the Purari Delta, west of the Elema, call the men's house *ravi*. The word *dubu* appears to be a Motu word applied indiscriminately throughout most of the Gulf and Central Districts of Papua to refer to men's club houses and/or ceremonial platforms (see Seligman 1910: 17–22, 60–65, 141–150). Usher was not always consistent in his use of these terms.

[4] These were registered A.47390–47467 and 48080–1.

> He has a good constitution which has withstood the dangers of a trying tropical climate as well as the more trying work he has had to face in surveying lines through dense jungle [and] almost impenetrable swamp.

On one his trips into the jungle, along the He Peri track, Usher came across a fungal growth that was particularly striking. His photographs lead us to believe that it is of the species *Dictyophora*, fairly common in areas of rich soil in sheltered spots such as rainforests; its odour is memorable, being foetid as of faeces or rotten meat.

Usher's eye for ethnographic detail and for everyday activities has provided us with a record of village life at that time: a boy wearing shell wealth ornaments (**D27**); a widow with tightly bound limbs and torso (**D30**) and another painted with clay (**C83**). Other images might still be captured today: an old man staring intently at the camera cradling betel-chewing equipment in his lap (**C26**); a woman washing her baby in the sea (**C50**).

A group of women cooking sago in pots (**A44**) and the image of a man using a bow and arrow (**A50**) show interdependence within family groups: the hunters providing high-prestige food (cassowary – **B119**, cuscus – **C29**) while the women and girls process sago (**B117–118, 163**). Another image shows a boy digging out turtle eggs from the banks of the Vailala River.

But life in Papua in 1914–16 was not one of work only; the indigenous people also knew how to have fun in play. A form of 'hockey' being played on the beach at the Vailala river mouth is shown (**A56**).

Fishing provided an important component in the diet of coastal villagers. In his book 'In Primitive New Guinea' (1924: 241), Holmes records:

> surf-fishing engaged in by young and old of both sexes at Orokolo, as well as at other villages along the coast, was done with the aid of conically shaped wicker fish-traps. Periodically shoals of a sprat-like fish named *avaha* were washed into the beach; their coming was hailed with delight by everybody, and whilst they were being caught by pouncing the traps into the water, seemingly at haphazard, with the hope of encircling and entrapping a few, excitement ran very high.

According to Holmes then, the task of gathering food was in some cases a source of fun for those engaged in it. Usher took a photograph at Ipisi village near Kerema of these conical fish-traps; he records on the back of the picture that 'the boys run rapidly through the water on seeing a fish, and bring down the basket-net over it; a hole at the top enables the fish to be got out'.

Holmes also mentions in his book (ibid.) that a Y-shaped frame was used for fishing, with a net stretched between the arms of the Y. This device was submerged and the fish scooped up to fall into the slack part of the net at the junction of the fork (**B87; D26**) so that they could not escape. One photograph (**A78**) shows the Y-nets and the conical basket fish-traps being used on the same occasion.

Another method of fishing used by men and boys was with the bow and arrow and spears (**B129**). One technique was to use an uprooted sapling with its stem driven at low tide into the sand to serve as a platform. The man would stand on the sapling's roots and shoot the fish from above (**B123**).[5] The skill lay in allowing for refraction through the water. This was less of a problem for those who chose to catch fish using spears with multiple prongs at the distal end (**A110**).

Another important source of food was sago. The swamps of the Purari Delta are rich in sago palms. The starch processed from the palm pith is a good staple food and was traded with the Motuans to the east for clay cooking pots. As noted above, the task of processing sago fell to the women but the men could process it if they were on a journey and short of food.

Holmes (1924: 252) described sago-making, which explains Usher's images (**B117–118**) of the process:

> [The equipment involved a] structure of troughs placed on firmly driven cross-sticks. The troughs were the butt-ends of midribs of sago-palms. They were so arranged that the smaller and outlet end of each sloped towards the other. The top trough held the sago pith, under its outlet was placed another trough which had a much greater slope, and under its outlet was the last trough, which rested, at its lower end, on a slightly tilted receptacle which had been made from the supple part of the spathe of a bastard palm. The smaller and outlet end of each trough was covered with gauze-like fibre obtained from coco-nut trees. This fibre acted as a sieve to prevent stray bits of pith from reaching the receptacle on the ground. The sago globules were extracted from the pith by the woman thrashing it with a long stick and by her frequently washing it

[5] This became a popular image of the Papuan fisherman early in the century (e.g. Holmes 1924, bookcover).

with water intermittently. The water carried the released sago with it through the sieves to the receptacle on the ground, where the latter remained as residuum, whilst the former slowly dribbled away as an overflow. The woman occasionally poured off the water, with her hands scooped up the sediment, put it into a plaited grass bag, suspended it to a branch of a tree, where, what water was still left in it could continue to drip away until only good edible sago remained.

The oil fields operation employed Papuan labourers, not only from the areas in which the oil exploration was being conducted but also from other administrative divisions, and these labourers brought their own tribal skills and traditions with them. The bridge built by Mambare men at Vivirai is but one example. A portrait of Bangoda, decorated as a Mambare warrior with face paint, a tiara of hornbill beaks ('signifying he has killed his man') and feather headdress, shows one of the bridge-builders dressed up for a sing-sing.

With the growing influence of missionaries of various nationalities and religious persuasions, traditional forms of clothing were supplanted by items of western dress. Usher encountered these people at a time when these changes were just beginning to have their effect on the Papuan way of life. One of the strengths of Usher's photographic work is his study of groups of people in traditional attire. These groups include families, boys, girls, men and boys together, women and babies, women and girls together, women involved in food preparation. Many of these groups are deliberately posed for the camera but are important studies of dress and adornment in a culture much changed.

A21 shows a family group at the village of Orokolo, sitting on the steps of the family home. Note the crescent-shaped pearl shell ornaments around the necks of both adults and children. The *kina* (pearl shell) seen in the Papuan Gulf region comes from either east of Port Moresby via the *hiri* trade, or from Torres Strait via the western Gulf trade links. In the Highland Provinces where these shells are scarce they take on greater value. In 1975, the newly independent nation of Papua New Guinea took the name of this shell currency as its major monetary unit, corresponding to the Australian dollar.

Usher also recorded ceremonial activities, important episodes in the rites of passage from childhood to adulthood. **B86** shows a boy who is going through the '*dubu*' (*eravo* - men's house) ceremony in Vailala village. If it was necessary for any of the initiands to leave the *eravo* and pass through the village, they had to be covered, i.e. their identities hidden, by wearing a *hara*, a cloak woven from the frond of a coconut (or perhaps sago) palm which concealed them from view.

An important Purari Delta ritual object was the roughly-woven cane 'monster' called *kaiaimunu* (**D28**) which 'devoured' the initiands during their seclusion in the *ravi* (men's house). The boys emerged from the *ravi* reborn, with glistening skin, bright shell and feather ornaments, and fore-and-aft '*ramis*' (Motu word for loin cloth) of bark cloth painted with rectilinear designs (**D21**), young men, as Usher noted on the back of the photograph, 'now eligible to marry'.

Usher did not have the good luck to witness the dancing of the Purari *aiaimunu* (or *hevehe* as they were known at Orokolo,[6] and *semese* at Vailala). These spectacular oval masks could be up to 8 metres tall. They were constructed by stretching bark cloth over a cane framework and marking out coloured designs by sewing on slender strips of cane. The South Australian Museum has one *aiaimunu* 2.8 metres high (**A.8554**) and another 1.2 metres high (**A.7422**), both probably from the inland Namau of the Purari Delta, obtained in the late 19th century; there are also two *kanipu* (**A.7420,–1**), much smaller versions of *aiaimunu*, from the same area.

Despite missing out on the performance of *aiaimunu*, Usher photographed a few tied to the front of dwelling houses at Maipua (**D2**) and inside a *ravi* (**D8**). These were of the coastal and inland Namau type respectively. During his survey along the coast from Vailala to Moresby, he also came across four men wearing a different type of mask at Koraita near Kerema (**B127**).

The interior of the *ravi* is shown in several photographs: **C81** at Iai (Iari) in the Purari Delta shows several carved and painted ancestral boards (*kwoi*)[7] in association with displays of human skulls; **D6** and **D17** (prints incorrectly number

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[6] The South Australian Museum has 27 glass plate negatives and one nitrate negative of photographs taken by F. E. Williams in Orokolo, mostly during his fieldwork in 1931–2. All were published in his book 'Drama of Orokolo' (1940) and for the most part concern the construction, dancing and destruction of the *hevehe* masks. These negatives are archived under the name of F. R. Vyse, Accession No.335.

[7] Called *gope* to the west of the Purari and *hohao* among the Elema to the east.

D17 and D6 respectively, by Usher) show several *kwoi* in association with pig and crocodile skulls on either side of the central passage of a *ravi* at Kairu; **D8**, taken in a *ravi* at Koropenaira, shows several *kwoi* and *aiaimunu*, a small mask called *kanipu* and, half hidden behind three handdrums, a carved and painted rectangular board that appears to be a shield remarkably like those to be found among the Fegolmin and Angkeiakmin of the Fly River headwaters in central New Guinea (cf. Craig 1988, fig.40). The *kwoi* bear carved and painted anthropomorphic, and sometimes zoomorphic, designs on wood recycled from old and broken canoes. The South Australian Museum has seven old ancestral boards (**A.7678–7684**) which from their designs appear to come from Orokolo or another nearby village in the lower Vailala River area (cf. Newton 1961, Figs 34, 43, 243–8). F. E. Williams, Papuan Government Anthropologist, described these boards (called *hohao* among the Western Elema of Orokolo where he did his fieldwork) as follows (1940: 154):

> The carving, deeply incised, depicts a highly conventionalized human face with forehead, eyes, nose, and mouth, together with a number of decorative additions. It is grotesque in the extreme, but not without its effectiveness in the total surroundings. In some rare cases a whole human figure is displayed; and in some others the flat board has developed into a figure carved in the round and bearing on the crown of its head a tousled mop of human hair.

The South Australian Museum has one such figure (**A.72748** – 1.43 metres high), male, but without the hair; it appears to be from Orokolo (cf. Newton 1961, Figs 249, 250). Another male figure (**A.33410** – 1.6 metres high) with hair attached, in an assymetric 'dancing' pose determined by the shape of the wood from which it was carved, is more likely from a coastal Namau village (cf. Newton 1961, Figs 212, 213) although it came to the Museum without provenance.

The inside of the men's house was divided into areas known as *larava*. Each clan in the tribe had its designated *larava*, and the clan *kwoi* or *hohao* boards were displayed in their particular areas. There were also small oval plaques of palm bark, carved and painted with face designs, attached to the men's house posts (see **D6**, taken at Kairu, inland Namau); the South Australian Museum has two of these (**A.7419, 7445** – cf. Newton 1961, Fig.231) which appear to come from the inland Namau. Two similar pieces (**A.7417, 7418**) but differing in being cut with leg-like forms at the bottom, are possibly canoe prow 'shields', not men's house post plaques.

The *larava* is where the men traditionally sat and talked. The *kwoi* or *hohao* were displayed in these areas unless the space was required for the giant *aiaimunu/hevehe/semese* masks, at which time the boards were placed in the dark and dusty recesses at the rear of the men's house amongst the rubbish. However, this does not mean that the boards were not revered; they were. Indeed, they had personal names and were of great significance, representing bush spirits associated with clan ancestors. Williams records (1940: 156) that an incident on a hunting trip could be followed by a dream in which a spirit instructs the man to carve a board to mark the occasion. This secret story of the *hohao* would be passed on from father to son, the board being kept in the *eravo* for many years. Two *kwoi* in Usher's photo **D6**, taken in a *ravi* at Kairu around Christmas 1915, are the same as two *kwoi* previously photographed by A. B. Lewis in May 1912 in the same *ravi* (Newton 1961, Figs 33, 218).[8] The differences in the *kwoi* displays over a short period of only 3½ years indicates something of the constantly changing nature of the *ravi*'s interior furnishings.

While creating a database for Usher's collection of J. W. Beattie postcards, the number of scenes which included canoes made it necessary to find out more about the various types. The standard work on canoes of Oceania, that by A. C. Haddon and J. Hornell, proved invaluable. A wealth of data can be found in or through that reference which explains several of Usher's images.

The largest canoe constructed by the Papuans was the multi-hulled *lakatoi* used in the *hiri*, the annual trading voyages by the Motu of the Moresby area in the east to the Elema and the Namau of the Vailala and the Purari Rivers in the

[8] cf. Newton 1961, plates 33, 218, which are reproductions of photographs taken by A. B. Lewis in 1912 for the Field Museum in Chicago, two years before Usher arrived. The *kwoi* to the left of the passageway in the first *larava* in Usher's photograph is in a corresponding position in Newton 1961, plate 33; the *kwoi* to the left of the passageway in the second *larava* in Usher's photograph is in a corresponding position in Newton 1961, plate 218.

west. The Motu took pots[9] and shell ornaments[10] and exchanged them for canoe hulls (*asi*) and sago, neither of which could be found locally. The *lakatoi* sailed to the Gulf villages as three- or four-hulled vessels and returned as reconstructed vessels with many more hulls.

Haddon and Hornell (1975: 227) report that the term *lakatoi* is derived from *laka* (Motu form of *wa, waka, waga* – a canoe with strakes), and *toi* (Motu form of *tolu* – three). Illustrations of *lakatoi* were most popular in books that dealt with this part of Papua and most visitors with cameras endeavoured to secure photographs of them.

Haddon and Hornell (op cit.) quote from Barton's account of the *hiri* included by Seligman in his book (1910: 96–120):

> A *lakatoi* is composed of three or more *asi* [dugouts], which are made of a soft-wood tree (*ilimo*) of great size that grows close by rivers in their low alluvial reaches in the Papuan Gulf district. The Gulf natives fell the trees and float them to the *lakatoi* that have arrived on a trading expedition (*hiri*). The trunks are hauled on to the bank of the river, where the visitors hollow them out and shape them. Fire is not employed in this operation. An *asi* is a clumsy dugout with rounded or squared ends prolonged above into a projecting flat beak. An unusually large one measured in 1886 had a length of 47 feet 8 inches from the tip of one beak to that of the other . . .
>
> The *asi* are secured together by numerous cross beams which are tied by lashings that pass through square holes cut in their gunwales. Over these beams a large platform or deck (*ilaha*) is constructed; this must be made very strong as it has to stand the strain of the great waves of the Gulf. The platform extends beyond the *asi* especially fore and aft. In 1884 the largest *lakatoi* which arrived at Port Moresby from the Gulf consisted of 14 *asi* and measured 59 by 51 feet; two smaller ones measured 54 by 37 feet.

Usher recorded four views of *lakatoi*. The first is of the central open deck space bounded by the large four-sided shelter that has been constructed on the multi-hulled vessel. The next image shows a fully-rigged *lakatoi* moored off the village of Kaimare in the Purari Delta (**C93**). The last two images (e.g. **C100**) are of a nine- or ten-hulled *lakatoi* moored beside Ukiaravi village in the Purari Delta, waiting for its load of sago to be brought in exchange for the pots and shell ornaments it has delivered. Barton gives a clear idea of the volume of trade involved (Seligman 1910: 114–5):

> The average number of men who go in a *lakatoi* is 29. In 1885 four *lakatoi* left Port Moresby each carrying an average number of 1628 pots. In 1903 the Kwaradubuna . . . equipped a *lakatoi* . . . consisting of 4 *asi*. The total number of pots carried in this *lakatoi* was 1294, giving an average therefore of 324 pots per *asi*. Assuming that 20 *lakatoi* sailed that year, and that each was composed of 4 *asi*, the total number of pots taken was 25,920. In addition to the pots the Kwaradubuna *lakatoi* took in that year 57 *toia*, 2 *mairi*, and 8 *tautau*, besides a certain quantity of trade tobacco and other imported articles. This vessel on her return voyage consisted of 10 *asi*, and her cargo of sago would therefore have been about 25 tons. Dr Lawson informed me that in 1884 the largest *lakatoi* consisting of 14 *asi* returned with 34 tons, and two others with 30 tons each.

The canoes of the Papuan Gulf were generally plain and practical although some of the larger dugouts had a panel of carved and painted designs along each side (**C91**). A single dugout for use in river travel was paddled along by people who stood in the canoe. For transport along the coast, outrigger canoes were used because they gave greater stability in the winds and strong currents found in the Gulf.

Apart from his interest in the indigenous inhabitants, Usher also noted the European presence on the outstations in the Gulf region (e.g. **C51–2**), in Port Moresby (especially a magnificent 6-frame panorama of the town) and at Herbertshöhe and Rabaul (e.g. **E33**). Other photographs record the visit to Port Moresby of the Admiral of the Fleet, Sir George E. Patey, K.C.M.G., K.C.V.O., R.N., Commander in Chief, Royal Australian Fleet, 1913/15. The visit was in August 1914, at the outbreak of the First World War. The people from the vicinity of Port Moresby put on a display of dancing to mark the occasion (**A146–7**).

The photograph **A147** (neg. A154) is an interesting study of the appropriation of a European artefact for an otherwise indigenous work. A close look at the headdress of the dancer on the right reveals the incorporation of a pack of

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[9] There were seven types of Motu pots (Barton in Seligman 1910: 114, fn.2).

[10] There were three main types of shell wealth: *toia* (shell armlets), *mairi* (pearl shells, whole or crescent-shaped), and *tautau* (nassa or 'dog-whelk' necklaces). A large *toia* bought a 250 to 350lb package of sago or one *asi* (canoe hull); a large *uro* pot bought a bag of about 80lbs of sago and a small *uro* pot or a *keikei* pot bought about 40lbs of sago (Barton in Seligman 1910: 115).

playing cards. Western icons became commonplace in tribal life over ensuing years and the nature of New Guinea art changed accordingly. The introduction of new objects and designs into a tribal society can be both challenging to tradition and a means of widening the horizons of the recipients.

> No matter how strong their traditions or how firm their faith in their own intrinsic worth, the people are now exposed and vulnerable and they must enter a new age if they are to survive into the future (Blackburn 1979: 15).

This meeting of two cultures should not necessarily be seen as negative although the asymmetry of power relations between colonisers and colonised meant that most of the change was carried by the colonised. It is safe to assume, however, that when the dancer in Usher's photograph conceived of the playing cards as components for his headdress, he didn't see the death of tradition but rather an opportunity to impress his audience with something novel.

Usher On Leave

Apparently, on his way home on leave some time in the first half of 1916, Usher (**E47**) travelled aboard the cargo boat 'Meklong' from Moresby to Herbertshöhe and Rabaul via Samarai, then called at Morobe and various other ports on New Britain, then on to the Shortlands off the southern end of Bougainville, and through the Solomons, presumably then on to Australia.

> The 'Meklong' was a cargo steamer with a carrying capacity of about 175 tons. Her hull was of iron, and she was capable of steaming seven knots in smooth water: if any sea was running, her speed became uncertain. Owned by the Norddeutscher-Lloyd, she had formerly been used for bringing rice down the Siamese river from which she took her name. In New Guinea she had been employed in collecting cargo from out-lying islands for transhipment at Rabaul to the Norddeutscher-Lloyd steamers, which connected the colony with the East and with Europe. Since her capture [in 1914 by HMAS 'Parramatta'] she had, after various naval and military services, been put back into the cargo trade, and Brig-Gen. Sir Samuel Pethebridge proposed to use her for the despatch of supplies to the islands, and for the concentration of copra at Rabaul for transhipment to Sydney. With her shallow draught, her small consumption of coal, and her comparatively large carrying capacity, the 'Meklong' proved a most servicable vessel in the work of the administration (Mackenzie 1938: 200–201).

It was probably this excursion that sparked Usher's interest in obtaining postcard photographs of these areas. Although Usher's trip through the Solomon Islands was fleeting, his photographs and his collection of Beattie postcards give us a record of life and culture in the islands around 1916. Among the images is a picture of two 'War' canoes that were kept in a canoe house on Vella Lavella (**F3**). These canoes are of the *mon* type, without an outrigger. Haddon and Hornell (1975: 108–9) have a description of an identical canoe housed in the British Museum that came from the the same island:

> Both ends are alike and rise into a high peak which is ornamented with *ovulum* shells along its outer edge and along the inner edge with triangular toothed pieces of shell. The sides are decorated with inlay. A bunch of feathers is on the tip of each peak.

Haddon reports (ibid.) that Carl Ribbe, in his book 'Zwei Jahre unter den Kannibalen der Salomo-Inseln' (1903), mentions that the *mon* canoes of Vella Lavella have two human heads facing fore and aft on the peaks of the canoe prows. This appears to be a visual reference to the headhunting activities of the owners of the canoe. Unfortunately the South Australian Museum's example (**A.8059**), obtained from Tost and Rohu in Sydney late last century, has lost the high peaks, ornamented with the *ovulum* shells, at each end.

Usher's Death

Ernest Sterne Usher died in Papua on 23 September 1916, not long after his return from leave. The following article appeared in *The Papuan Times* on 4 October 1916:

BOATING FATALITY

> News has been received of the death by drowning of Mr A. [sic] Usher, surveyor to the oilfields. This gentleman has been engaged in cutting a new road at the back of Orokolo to a new bore site. Mr Usher was drowned whilst crossing the Vailala river from the western side at its mouth. There was a fresh[11] in

[11] 'Fresh': a sudden rise in water level caused by overnight rain upstream. Tidal bores also are a dangerous phenomenon in rivers draining south into the Gulf of Papua. It was a tidal bore that swept Michael Rockefeller and his companions out to sea during his work among the Asmat of Irian Jaya; presumably he drowned when he attempted to swim back to shore.

the river at the time, resulting in a very strong current. The deceased attempted to cross in a small canoe with three boys. He was warned by the Village Constable to obtain a larger canoe, but replied that a smaller one would be quicker. The canoe was swamped, and the current swept the unfortunate man out to sea. He endeavoured to swim ashore, but became exhausted and sank. His body has not been recovered so far. Two natives reached the shore in an exhausted condition, but the third boy was drowned, and his body washed ashore two days later.

Mr Usher was extremely popular on the oilfield, and only returned to the oilfields three months ago after a holiday south. The sad news of his death caused a feeling of depression on the field, where his many friends heard the news with the greatest regret.

Discussion

Research on the Usher collection continues. Although most of the photographs have something written on the back and there is a short description of each photograph in a list for each of the alphabetic series, we do not know what became of his field diaries which he would have kept to document his survey observations. They were probably taken over by Wade but we have yet to locate Wade's diaries and records. The present numbered sequence of the photographs is not always consistent with the few facts we do know of Usher's itinerary. It is possible that we could get a clearer idea of the sequence of the photographs from Usher's field diary, even if he did not record each day exactly when and where he took each photograph.

Nevertheless there is sufficient data in the images to throw light on the nature and significance of undocumented or incorrectly described ethnographic objects held by museums (as noted above for the long narrow carved boards in the Webster catalogue), and to conduct a comparative study of ethnographic material over space (that is, comparing the material culture of people in several neighbouring communities) and over time (by looking for images from a number of photographers showing the same place at different points in time). The comparison of Usher's **D6** with certain photographs by Lewis 3½ years earlier has identified two *kwoi* apparently in the same men's house but in association with different *kwoi* on each occasion. Usher's photographs taken at Kaimari in 1915 (C93, 97,98) may be compared to Hurley and Williams photographs taken at Kaimari seven years later.[12] Thus there is much scope for comparing the photographs of Lewis, Usher, Chinnery, Hurley, Wirz, Williams, and perhaps others not yet identified, to elicit information on continuity and change in the cultures of the region.

The Usher collection is one man's window on cultures that have existed for hundreds if not thousands of years, cultures that have not been static but responsive to changes in the environment, to impacts from outside and to impulses from within. We do not know exactly why Usher set about making such a thorough photographic record. Was it simply curiosity? Was it a way of letting his family know what he was doing? Did he have some grander purpose? These photographs join other major collections of photographs of the colonial era that provide the data for analysis of the way Europeans have viewed tribal peoples in the Pacific (and indeed elsewhere in the world). This paper has not attempted such an analysis but the brief notes attached to Usher's images do suggest to the authors that his attitude towards the indigenous people was positive and his aim consistent with an ethnographic purpose of recording the lifeways of people still living more-or-less as their ancestors lived before Europeans came to work among them. This record will undoubtedly be of considerable interest to the descendants of those people and it is intended to explore means for making the photographs accessible to them.

[12] E.g. Hurley: V.4867, V.4873 in Specht and Fields 1984: 167, 169; Williams: Australian Archives A6003/37.3.

Index To Usher Photo Albums A To F

ALBUM A	LOCATION	USHER'S DESCRIPTION	INDEXER'S NOTES
A1–4a,b	Melbourne, VIC.?	[Family photos; Melbourne?]; June 1916	Negatives only
A5	Upoia, Vailala River	White quarters	
A6	Upoia	Weekly muster of labourers	
A7	Upoia	Inspection of police and rifles	
A8	Upoia	Looking upstream at camp and Vailala River	
A9	Upoia	Boys houses at Upoia	
A10	Upoia	Main camp; view from west side	Destroyed
A11	Upoia	Setting off from Upoia to Aro Aro January 1914	
A12	Parimanurri, Vailala District	Crane and Wrathall paying women carriers.	Mr W.J. Crane was Patrol Officer from 6-7-14 to 3-3-15
A13	Parimanurri	Village scene	
A14	Parimanurri	Camp at Parimanurri	Destroyed
A15	Parimanurri	Survey camp	
A16	Parimanurri	Dubu at Parimanurri; the completed building will extend to the front posts.	
A17	Orokolo, Vailala District	Typical dubu at Orokolo Village	
A18	Orokolo	Traders house (Mr McDonald's) at Orokolo	
A19	Orokolo	Sunday School at London Missionary Society Mission, Orokolo (Tongan missionary), showing wreck of Burns Philp ketch 'Gira', with Crane, McDonnell and Wrathall on deck	
A20	Orokolo	Village scene	
A21	Orokolo	Family group	
A22	Orokolo	Village scene	
A23, 24	Ferntree Gully, VIC.	[Family photos, Ferntree Gully picnic]	Negatives only
A25	near Muru village	Bush track scene	
A26, 27	Muru village	Group on dubu; family group	Destroyed; replaced with negatives of family photos, Ferntree Gully picnic, Victoria
A28	Muru village	Man climbing coconut tree . . . notice breadfruit trees and method of marking coconut tree for ownership	
A29	Muru village	Well-constructed typical dubu	Destroyed (but see A48)—replaced with negative of family photo of Joan
A30	Heperi Camp	White bell-shaped fungus	
A31	Ravi Ravau village, Purari Delta	Village scene with canoes—all paddling is done standing up.	
A32, 33	Ravi Ravau village, Purari Delta	Village scene with canoes	
A34	Aiari village, Purari Delta	Interior of dubu	Destroyed—replaced with negative of family photo of Joan, Marion and Edith
A35	Maipua village, Purari Delta	Panorama taken from rocking canoe	Destroyed—replaced with negative of family photo of Joan
A36	Vivirai, Vailala River	Bridge built by Mambare Boys at McDonald's	'Boys' = men
A37	Vivirai camp	Bridge built by Mambare Boys, Vaivira camp (McDonald's)	'Boys' = men
A38	Vivirai camp	River Scene looking up Vailala River from McDonald's (Vaivira)	On negative, says 'Maira, V.O.'

A39–41	Maira camp	Views from Maira Camp and among sago palms along Maira track	Destroyed—replaced with negatives of family photos of Joan
A42	Vailala village	Group of boys	
A43	Vailala village	Group of girls; notice method of shaving head	
A44	Vailala village	Women preparing for a banquet—note village dogs and cooking pots	
A45	Vailala village	Preparing banquet	
A46	Vailala village	Cooking scene	
A47	Vailala village	Big dubu	Destroyed
A48	Idikaku village, Vailala River	Well constructed typical dubu, near Lett's	
A49	Idikaku village	Group of men and boys	
A50	Idikaku village	Man firing bow and arrow; near Lett's	
A51	near Mairu, Vailala River	Forest track scene between Lett's and Maira	
A52	Vailala River	Shifting camp by whale boat, Lett's.	Destroyed
A53	Vailala River mouth	Mid-day meal at Rest House; C. Henry (P.O.) standing; L. L. Wrathall and E. R. Stanley sitting; cook boys Heraciou and Toi.	
A54	Vailala beach	Fishing boys	Destroyed—replaced with negative of family photo of Marion and Joan
A55	Vailala?	My survey boys—left to right, Kao-I, Kebe, Ikavu, Obovda, Bets	Destroyed—replaced with negative of family photo of Joan
A56	Vailala River mouth	Hockey on the beach —photo taken at nearly sunset	'boys' = men
A57	Vailala River mouth	Towing the stranded 'Orokolo' through the surf to the Vailala mouth; notice three tow lines and boys keeping boat in deep water	
A58	Vailala Beach	Group of boys and girls; 'Orokolo' ketch in background being dragged along by natives	
A59	Vailala River mouth	Towing the ketch 'Orokolo' into the river	'boy' = man
A60, 61		Mambare 'boy' (Bangoda) in dancing costume – notice bills of Hornbills signifying that he has killed his man	
A62	Koraita village, near Kerema	Woman and very young child	
A63, 64	Koraita village	Family groups	Destroyed
A65	Ipisi village, near Kerema	Children	
A66, 67	Kerema	Woman and child; women on canoe	Destroyed
A68	Ipisi village	Fishing boys; the boys run rapidly through the water on seeing a fish and bring down the basket over it—a hole at the top enables the fish to be got out.	
A69	Koraita village	Women and children digging in the sand for Lingulae (very ancient form of brachiopod)	
A70	Kerema	Mambare boys dancing	'boys' = men
A71	Kerema	Mambare boys ready to dance	'boys' = men
A72	Kerema	Mambare boys ready to dance	Destroyed
A73	Ipisi village	Woman carrying firewood and baby	
A74, 75	Kerema	Groups [of people]	Destroyed
A76	Kerema	Large group of fishing people after a shoal of fish	
A77	Kerema	Group of fishermen	
A78	Kerema	Fishing boys	
A79	Kerema	Women carrying evening meal (sago and potatoes)	in pots
A80	Koraita village	Women returning with a load of shrimps	in canoe
A81, 82	Kerema	Group of police with Magistrate (Mr J. F. Keeland)	
A83	Koraita	Women cooking shrimps in leaves—smoke in centre of picture	

A84	Kerema	Police sergeant and wife at Kerema government station	
A85	Selon [?] village	Group [of people]	Destroyed
A86	Kukipi	Loading canoes at Kukipi for transport	
A87	Motu Motu	Motu Motu boys interested in a theodolite	
A88	Motu Motu	Group of girls making ramis	
A89	Motu Motu	Women stripping leaves from a sago palm for making grass skirts [ramis]; notice heads of all showing various styles of cutting hair	
A90	Lese village	Lese Village	Negative missing
A91	Lese village	Transport by canoes (Max Aspin's store); my survey boys (Mambares) in front with theodolite and other equipment	
A92	Mairu village	Women and babies	
A93	Mairu village	Fishing boys using bows and arrows at Mairu village	
A94	Lese village	Widow at Lese village	
A95	Lese village	Woman and child at Lese village	
A96	Lese village	Man and child	Destroyed
A97	Moru village	General view	Negative missing
A98	Moru village	Baby	
A99	Moru village	Cooking scene	
A100	Moru village	Picanninny [sic]	
A101	Moru village	Widows and children	
A102	Moru village	Village scene	
A103	Sepoi village	Village scene	
A104	Sepoi village	Group of women	Negative missing
A105	?	?	Destroyed
A106	Sepoi village	Samoan missionary's house	
A107	Sepoi village	Mission children	
A108	Kivori village, near Cape Possession	General scene; note: wind screens, fenced houses which are right on the ground	
A109	Kivori village	Group of well tattooed women	Tattoo markings do not show well
A110	Sepoi village	Men spearing fish	
A111	Sepoi village	Group of natives on the beach	
A112	Mairu village	Youthful couple	Toddlers
A113	Mairu village	Preparing for a feast	
A114	Mairu village	Group of men	
A115	Berena village	Native graveyard at Berena Village, west of Yule Island; the roofs over the graves vary from 5ft to 7ft high	Negative missing
A116	Kerema	Portrait of C. Henry, Ass. Resident Magistrate, Kerema	Destroyed (but see A130)
A117	Berena village	Picanninny	
A118	Berena village	General scene	
A119	Berena village	Dubu, houses, and baggage	
A120	Berena village	Washing baby who is vigorously protesting; note deep tattooing on the women	Tattoo markings do not show well
A121	Kivori village	Group of tattooed women	Tattoo markings do not show well
A122	Maiva village	House with garden	
A123	Kivori village	Back view of tattooed women	Tattoo markings do not show well
A124	Maiva village	Well kept native house	
A125	?	Young boys spearing and rolling coconuts at village; one boy stands at the side and rolls the coconut rapidly along the ground—they are remarkably good shots	

A126	near Berena village,	Mid-day halt with carriers	
A127	Mohu (Mou) village, near Yule Island		General view
A128	Mohu (Mou) village	Typical dubu	
A129	Mohu (Mou) village	Group of men and women (carriers) . . . C. Henry in front	
A130	Kerema	Portrait: C. H. Henry	Arrived 14th July 1914 as Assistant Resident Magistrate, Gulf Division
A131	Pinnapaku	Well decorated, tattooed women from Mou village	Tattoo markings do not show well
A132	Yule Island	Picanninny at village about 1.5 miles from Yule Island Mission Station	
A133	Yule Island	Group of young children at Yule Island Village	
A134	Yule Island	(Men) Boys building a house at Yule Island Village	
A135	Yule Island	Typical Dubu at Yule Island village	
A136	Yule Island	General view of Yule Island Mission Station (R. C. Sacred Heart Mission)	
A137	Yule Island	General view of Yule Island looking from flagstaff of Government Station towards Mission Station – Ketch 'Sir Arthur' in foreground	
A138–142	Port Moresby	Panorama of Port Moresby looking from Mr Staniforth-Smith's home towards land office [then 180° to right over the town to Ela Beach and coastline beyond]	Negative sequence 139, 140, 143, 142, 144
A143, 144	Port Moresby	Panorama of Port Moresby looking from behind Hospital towards Paga Hill [left to right]	Another list says 'from behind Government Secretary's Office'; negative sequence 141, 138
A145–169	Port Moresby	Dancers at Police Barracks, Port Moresby, in honour of the first visit of the Admiral of the Australian Fleet, July 1914	Negative sequence: 151, 168, 154, 148, 159, 158, 157, 156, 155, 152, 153, 149, 145, 147, 163, 165, 160, 162, 161, 164, 146; negatives of 159, 160, 168 missing, and print and negative of 164 destroyed
A170–173	Port Moresby	[Left to right] Panorama of Elevara, Hanuabada and Comdobu [Konedobu?] at Port Moresby	NB. London Missionary Society Church in 172; negative for 173 missing
A174–176	Port Moresby	As above	Destroyed
A177	Near Port Moresby	Group of natives at village near Port Moresby	
A178	Near Port Moresby	General view of village near Port Moresby	Negative A185
A179	Near Port Moresby	Father and son, Hanuabada	
A180	Near Port Moresby	Natives, village near Port Moresby	Negative missing
A181, 182	?	Woman and baby	Destroyed
A183	Port Moresby	Woman and child, Hanuabada	
A184	Port Moresby	Portrait : J. W. Murray	Negative missing
A185	Port Moresby	General view—village near Port Moresby	Negative A178
A186	Hanuabada	Picanninny [sic]	Destroyed

A187	Heperi village, Vailala	E. S. Usher on dubu at Heperi village	Negative missing
A188	Port Moresby	H.M.S. 'Encounter' showing view of Fairfax Harbour	Negative A189
A189	Port Moresby	H.M.S. 'Encounter' entering Port Moresby Harbour on the occasion of the first visit of the Admiral to Papua, July 1914	Negative A190
A190	Port Moresby	View of Port Moresby Harbour looking towards Titava Island	Negative A188
A191	Port Moresby	Wharf, Port Moresby, decorated for visit of Admiral of the Fleet	
A192	Port Moresby	Port Moresby—Papua	Burns Philp store with tower, at right
A193	Port Moresby	General scene—Hanuabada, Port Moresby	
A194	Port Moresby	Portrait: E. S. Usher	Destroyed
A195	Port Moresby	Portrait: L .L. Wrathall	
A196	Port Moresby	Portrait: Dr Arthur Wade	
A197	Port Moresby	Portrait: Evan Richard Stanley	
A198	Port Moresby	Portrait: J. W. Murray	
A199	Port Moresby	Portrait: E. S. Usher	
A200	Port Moresby Papua	Group photo of Wade Oil Expedition members, Rear: Wrathall (left), Murray (right); middle, left: Usher; front: Stanley (left), Wade (right)	

ALBUM B	LOCATION	USHER'S DESCRIPTION	INDEXER'S NOTES
B1, 2	Port Moresby	S.S. 'Kanowna' Troopship coming into Port Moresby—outbreak of War, August 1914	
B3, 4	Port Moresby	Troops on S.S. 'Kanowna'	
B5, 6	Port Moresby	Torpedo destroyers alongside 'Kanowna'	Destroyed
B7	Port Moresby	Australian Troops drilling at Port Moresby (in groups across the landscape)	
B8	Port Moresby	Australian troops at Port Moresby; left of centre: others in groups under trees	
B9–12	Port Moresby	Australian troops drilling at Port Moresby at the outbreak of War	
B13, 14	Port Moresby	Heliographers at work	
B15	Port Moresby	Red Cross Corps—Port Moresby	
B16–18	Port Moresby	Torpedo destroyers at Port Moresby	Destroyed
B19	Yule Island	Canoe scene—Yule Island	
B20	Yule Island	Canoe scene—Yulė Island	
B21	Yule Island	View of Roman Catholic Sacred Heart Mission Station taken from the sea at Yule Island	Negative missing
B22, 23	Aidana village	Scene at Aidana village near Port Moresby – panorama [right to left]	'Quarabada' on negatives and list
B24	Aidana village	Group of young children at Aidana village	
B25	Aidana village	Group of young boys at Aidana village	
B26	Port Moresby	Church of England—Port Moresby, August 1914	
B27–29	Port Moresby	Start of first railway in Papua—Port Moresby, August 1914	
B30	Port Moresby	Coast scene near Koki	Destroyed
B31	Upoia?	View from house looking towards river, Feb. 1915	Destroyed
B32	Upoia	New house, Feb. 1915	Destroyed
B33	Kerema?	Mr Massey-Baker in canoe, Feb. 1915	Destroyed
B34	Kerema	Government station , Kerema, Feb. 1915	Destroyed
B35	Ipisi village near Kerema	Baby, Feb. 1915	Destroyed
B36	Ipisi village	Boys playing in surf, Feb. 1915	Destroyed
B37	?	Cutter Nouei [?] from 'Ela', Feb. 1915	Destroyed
B38	Vailala River mouth	Natives dressing to go home, August 1914	
B39	Vailala River mouth	Natives transferring goods to canoes from launch, August 1914	

B40	Vailala River mouth	Off for home in canoes, August 1914	
B41	Vailala River mouth	Canoes coming out to meet boat, August 1914	
B42	Upoia	Launch 'Ela', August 1914	
B43	Koraita near Kerema	Canoe building, August 1914	
B44	Koraita	House (dubu) in building, August 1914	
B45	Upoia	Unloading cargo at Upoia, Vailala Oilfields	
B46	Upoia	Distributing weekly allowance of tobacco, matches etc.	
B47	Near Port Moresby	Woman and child—village near Port Moresby	
B48	Near Port Moresby	Old couple—village near Port Moresby	
B49	Near Port Moresby	General view—village near Port Moresby	
B50	Near Port Moresby	Street scene—village near Port Moresby	
B51	Near Port Moresby	View to coast from village near Port Moresby	Destroyed
B52	Near Port Moresby	Village scene near Port Moresby	
B53	Upoia	Large rubber tree showing aerial roots—Upoia	
B54	Upoia	Boys road making at Upoia	
B55, 56	Upoia	Transporting boring plant—Upoia, Sept. 1914	
B57	Upoia	Boys going to work—Upoia, Sept. 1914	
B58	Upoia	View from bore site No.6 to white quarters, Sept. 1914	Destroyed
B59	Upoia	View from bore site No.6 to white quarters, Sept. 1914	
B60	Upoia	View from white quarters to river, Sept. 1914	Destroyed
B61	Upoia	View from white quarters to river, Sept. 1914	Negative missing
B62, 63	Upoia	View from white quarters to river, Sept. 1914	Destroyed
B64	Purari village, Vailala River	Two old women	
B65	Purari village	Native house and group	
B66	Purari village	Group of women	
B67	Purari village	Group of men	
B68	?	A mid-day halt on Purari trip—J. W. Murray on whaleboat	
B69	Vailala River	View of Vailala River from white quarters looking south	
B70, 71	Akauda village, Vailala River	Group of women	
B72, 73	Hahia village	View from Hahia village looking towards Upoia	Destroyed
B74	Upoia?	Group taken at departure of Mr C. H. Locke	Destroyed
B75	Urawoi village	Group of men and carriers, Oct. 1914	
B76	Urawoi village	Group of women, Oct. 1914	
B77	Borki village, Vailala River	Group of old men, Oct. 1914	
B78	Borki village, Vailala River	Group of children, Oct. 1914	
B79	Urawoi village district	Fish traps across creek, Oct. 1914	
B80	Urawoi village district	Large rubber tree with aerial roots, Oct. 1914	
B81–83	Between Upoia and Borki	Rock exposures between Upoia and Borki, Oct. 1914	
B84	Between Upoia and Borki	Survey group on Stadia Traverse of Vailala River, Oct. 1914	
B85	Upoia	Smiths (Dullers') house, Oct. 1914	
B86	Vailala	Boy who is going through dubu ceremony, Oct. 1914	Negative missing
B87	Vailala village	Fishing women, Oct. 1914	
B88	Vailala village	Dubu under construction, Oct. 1914	
B89	Vailala village	Group of young children, Oct. 1914	
B90	Vailala River	Hunting for turtles eggs, Oct. 1914	
B91	?	Kiwi boys shaving with broken glass, Oct. 1914	
B92, 93	Upoia	Group of white residents Upoia	
B94	Vailala village	Woman with elephantiasis	Destroyed
B95	Upoia	Portrait of J. Hodges	Destroyed
B96	Vailala village	Women cutting hair	Destroyed

B97	?	Nobigu, my cook boy	Negative only
B98	Ivori River	Murray Falls on Ivori River (Mr Massey-Baker, R. M.), Nov. 1914	
B99	Hukerara village, Vailala River	Tree house, Nov. 1914	
B100	Vailala River	Canoe scene, Vailala River near Ivori River, Nov. 1914	
B101	Keki village, upper Vailala River	Vailala River looking upstream from Keki village, Nov. 1914	
B102	Paku village, upper Vailala River	Village scene, Paku village, Nov. 1914	
B103	Keki village	Village scene, Nov. 1914	
B104	Junction of Dahile and Vailala Rivers	Junction of Dahile and Vailala Rivers, Nov. 1914	
B105	Junction of Vailala and Ivori Rivers	Junction of Vailala and Ivori Rivers, Nov. 1914	
B106	Upoia	Creek scene near Upoia, Nov. 1914	
B107	Upoia	Creek scene near Upoia showing very dense scrub, Nov. 1914	
B108	Ivori River	Scene on Ivori River—furthest north, Nov. 1914	
B109	Ivori River	Scene on Ivori River, Nov. 1914	
B110	Upoia	Tree observation tower station—Upoia, Dec. 1914	
B111	?	Nobigu and lady	
B112–114	?	?	Destroyed
B115	Upoia	Cook boys—Upoia; (left to right) Kio, Aupa and Ompe	
B116	Horu village near Upoia	Women making sago	
B117	Horu village	Woman making sago	
B118	Horu village	Woman making sago	
B119	Habia Camp	Boys with cassowary	
B120	Horu Village	Woman making basket	
B121	near Habia	Scene among bamboo	
B122	Keuru (between Vailala River and Kerema)	Crossing creek near Keuru, Feb. 1915	
B123	Keuru	Man shooting fish, Feb. 1915	
B124	Keuru	Motu-Motu canoe poling along coast, Feb. 1915	
B125	Keuru	Cave in Limestone near Bluff, Feb. 1915	
B126	Koraita near Kerema	Dancing men, Feb. 1915	
B127	Koraita	Dancing men, Feb. 1915	
B128	Koraita	Dancing men entering dubu, Feb. 1915	Destroyed
B129	Kerema	Boys spearing fish near Kerema, Feb. 1915	
B130	Kerema	Boys scrambling for tobacco, Feb. 1915	
B131	?	Man with Elephantiasis, Feb. 1915	
B132	Kerema	View from Kerema Station looking north, Feb. 1915	Destroyed
B133	Kerema	View from Kerema Station looking north, Feb. 1915	No print
B134a,b	Kerema	View from Kerema Station looking towards Mai [?] Point, Feb. 1915	No prints; two negatives, probably left to right panorama
B135–139	Upoia	Panoramic view from tree trig station, Upoia, for photographic survey work [left to right]	No prints; 135 destroyed; two negatives each of 136 and 138 (second with filter used)
B140–147	Upoia	Panoramic view from Bald Hill, Upoia, for photographic survey [left to right]	No prints; 147 destroyed
B148	Upoia	White bell fungus near Upoia (photographed from nature)	

B149	Upoia	Verandah scene at Upoia	No print
B150–151	Upoia	Panorama of Oilfield from behind Smith's house [left to right]	No prints
B152	Upoia	View towards Albert Ranges from Bald Hill	No print
B153–155	Upoia	Cloud studies	No prints
B156, 157	near Dua village	Women breaking down sago pith, March 1915	Destroyed
B158, 159	Dua Creek	Rock outcrop on Dua Creek near Gorge, March 1915	Destroyed
B160, 161	Ahia [?] village	Panoramic views from [?]Ahia village looking east [left to right]	No prints
B162	Upoia	Mess table, Upoia—J. Hodges, R. Bannon	
B163	Dua Village	Women breaking down sago pith near Dua village	
B164, 165	Dua village	View of camp near Dua village, March 1915	Destroyed
B166, 167	?	Still life study—Monkey Bar	Destroyed
B168–170	Borki	Scenes on Billabong near Borki, April 1915	
B171–173	Vailala River	Swamp tree (mangrove roots); moving camp by canoe	Destroyed

ALBUM C	LOCATION	USHER'S DESCRIPTION	INDEXER'S NOTES
C1	Orokolo	Church, London Missionary Society Station, Orokolo	
C2	Upoia?	Our white cook, T. McGowan [?]	Destroyed
C3	Upoia, Vailala River	Canoe scene	No print
C4	Upoia, Vailala River	Group of natives on riverbank	No print
C5	Upoia, Vailala River	Two natives on riverbank	No print
C6	Upoia, Vailala River	Canoe scene	No print
C7	Vailala River	Group of canoes and men	No print
C8	Vailala River	Canoe scene, Vailala river	No print
C9	?	My survey boys (left to right) Itori, Woro, Kelala, Hamoi and Dia	Negative numbered C10
C10	near Upoia	Track scene near Upoia on the Aro Aro track	
C11	near Upoia	Surveying new road, Upoia to the coast	
C12	?	Man and woman cutting up sago palm	Photo and negative missing
C13	?	Boy climbing coconut tree	
C14	Vailala river	Vailala river looking south from Letts	
C15	near Upoia	Camp scene	
C16	near Upoia	Prolific Poa Poa [pawpaw] tree	
C17	?	My cook boy Nobigu in dancing costume	
C18	Upoia	White quarters, Upoia (old style native house)	
C19	Upoia	Survey boys and survey canoe	
C20, 21	Upoia	Fault in rocks near Upoia—dull wet weather	
C22, 23	Upoia	Moving camp by canoe—Upoia	
C24	Nepaga village, Vailala River mouth	Scene at Nepaga village creek	
C25	Nepaga village	Old man	
C26	Nepaga village	Old man	
C27	Ijori village	Village scene—crotons	
C28	Nepaga village	Young boy with ulcers	
C29	Nepaga village	Two hunters with cuss-cuss	
C30	Maiva village, Mekeo district	Village scene	
C31	Berema village, Mekeo District	Roman Catholic Mission at Berema village	
C32	Berema village	Village scene	
C33, 34	Maiva village	Scenes at Maiva village	
C35	Kivoori Poe village near Yule Island	Women cutting little girls hair	
C36	Kivoori Poe village	Samoan Mission house	Negative missing
C37	Cape Possession	Cape Possession Beds	

C38	Yule Island	Outcrop of rock	
C39	Chiria Village, Yule Island	Old woman making pottery	
C40	Yule Island	Rescuing a horse	Negative missing
C41	Berena village.	Women tattooing	No print
C42	Yule Island	Scene at Yule Island looking towards Delena	
C43	Helau village, Vailala river mouth	Dubu at Helau village	
C44	Mohu village, Mekeo District	R.C.Mission at Mohu village	Photo and negative missing
C45	?	Portrait of two Mekeo boys	
C46	Mohu creek, Yule Island	Market scene, Mohu creek	
C47	Maiva village	Men with spears and shield	Negative missing
C48	Maiva village	Boys with bows and arrows	
C49	?	L. L. Wrathall off to enlist	
C50	Pinnapaka village, near Yule Island	Washing baby	
C51	Orokolo	Lawrence Schlenker, Orokolo, London Missionary Society	
C52	Orokolo	London Missionary Society Station, Orokolo	
C53	Biai	Dubu at Biai, sleeping quarters for G. Bryson (Appendicitis Hospital)	
C54	Vailala River mouth	Man with Elephantiasis	
C55	Vailala River mouth	Launching whale boat	
C56	Vailala River mouth	Launching a canoe log	
C57	Vailala River mouth	Women fishing in lagoon	
C58	Upoia	No.6 Bore, Upoia	
C59	Upoia	Tramway scene, Upoia	
C60	Vailala	Oilfield Launch, 'Vailala'	No print
C61	Vailala	Oilfields Launch ..	No print
C62, 63	?	Scenes in swamp showing Flying Foxes	No print of 63
C64	Vailala River	Vailala River scene, Loop No.2	
C65	Vailala River	Skipper and engineer of launch, 'Vailala'	Photo and negative missing
C66–68	Vailala	Photo of trees on road from Upoia to coast	No print of 68
C69	Vaiviri	McDonald's house, Vaiviri	
C70	?	Moresby Gifton on Launch 'Vailala'	
C71, 72	Vailala Oilfield	Bridge on the Upoia to Vaiviri track, Vailala Oilfield	C71 destroyed
C73	Vailala Oilfield	Large tree on the Upoia to Vaiviri track, Vailala Oilfield	Destroyed
C74	Purari Delta	Photographic expedition in Purari Delta, Christmas 1915	
C75	Iai village, Purari Delta	Iai village	Negative missing [Iai=Iari?]
C76	Iai village	Old men	
C77	Iai village	Young boys	
C78	Iai village	Young men	
C79	Iai village	Women and children	
C80	Iai village	Old men	
C81	Iai village	Interior of dubu (irava or men's club house)	Negative missing
C82	Iai village	Iai village Purari Delta	
C83	Iai village	Three women; centre one [is] a widow covered with white clay.	
C84	Kairu village, Purari Delta	Creek scene near Kairu village	Photo and negative missing
C85	Kairu village	Old men	
C86	Kairu village	Dwelling houses	
C87	Koropenaira village, Purari Delta	Aimunu (captives basket)	Koropenairu on maps

C88	Iai village	Village scene	
C89	Iai village	Canoe scene	
C90	Urika, Purari Delta	London Missionary Society station	
C91	Maipua village, Purari Delta	Returning from the gardens	
C92	U-Ki-Aravi village	Interior of lakatoi—showing method of housing	= U-k-iaravi (see C99,100, D3–7, etc)
C93	Kaimari village, Purari Delta	East End lakatoi at Purari Delta	Kaimare village; cf. C97
C94	Kaimari village	Street scene	
C95	Kaimari village	Women at Kaimari village	
C96–98	Kaimari village	General scene—panorama	C96 photo and negative missing
C99, 100	U-k-iaravi village	A lakatoi from East End of Papua waiting in Purari Delta for a load of sago given in exchange for load of pots and other trade goods	C99 negative missing

ALBUM D	LOCATION	USHER'S DESCRIPTION	INDEXER'S NOTES
D1	Maipua village, Purari Delta	General village scene at Maipua	
D2	Maipua village	Dwelling houses at Maipua	
D3	U-k-iaravi village, Purari Delta	Irava (club house)	A-ki-ravi or Ukai-ravi ? Negative missing
D4	U-k-iaravi village	General scene	
D5	U-k-iaravi village	Lakatoi, lakatoi house and canoe	cf. C99–100
D6	U-k-iaravi village	Interior of club house (irava)	Print incorrectly numbered D17 by Usher
D7	U-k-iaravi village	Front view of Kai-aimunu basket—flashlight photo taken in club house	Same as C87; suspect original D7 photo and negative destroyed
D8	Koropenaira village, Purari Delta	Interior of club house	
D9	U-k-iaravi village	Lakatoi at U-k-iaravi village	
D10	U-k-iaravi village	U-k-iaravi village showing large irava	
D11, 12	U-k-iaravi village	Two old men	
D13	U-k-iaravi village	Lakatoi at U-k-iaravi village	
D14, 15	near Urika Island, Purari Delta	Sago making	
D16	Kairu village, Purari Delta	Dwelling houses	
D17	Kairu village	Interior of irava or club house	Print incorrectly numbered D6 by Usher
D18	Kaimari village, Purari Delta	Two men, Kaimari village. Smaller one covered with clay being in mourning for a relative.	
D19	Kaimari village	Women at Kaimari village.	
D20	Kaimari village	Street scene	
D21	Orokolo village	Youths just out of irava	List states 'Ari-hovi village' [=Api-Opi?]
D22	Kaimari village	Hanuabada natives off Lakatoi at Kaimari village	
D23	Orokolo	Youths just out of irava where they have been confined for months; front view	List states 'Ari-hovi village' [=Api-Opi?]
D24	Orokolo	Youths who have just come out of the irava or club house after confinement of many months, now eligible to marry; back view	List states 'Ari-hovi village' [=Api-Opi?]
D25	Maipua village	Making sago with the feet	
D26	Orokolo village	Women fishing	
D27	Kaimari village	Young boy	Second negative D27 (no print) same subject slightly different position

D28	Ravi Kavau village, Purari Delta	Aimuno (Captives baskets)	
D29	Maipua village	Old man with piebald skin	Second negative D29 (no print) same subject slightly different position
D30	Maipua village	Widow	
D31	Orokolo village	Old woman with long curls	
D32	Orokolo village	Women returning from gardens	
D33	Orokolo village	Women fishing.	
D34	Orokolo district	Man with elephantiasis of legs	No print
D35	Orokolo district	Village Constable	No print
D36	Vailala village	Group of youths	No print
D37, 38	Samarai	Samarai, general views	
D39	Samarai	Samarai, view west side	
D40	Samarai	Scenic track among the coconuts, Samarai	
D41	Samarai	An avenue in Samarai	
D42	Samarai	Church of England in Samarai	

ALBUM E	LOCATION	USHER'S DESCRIPTION	INDEXER'S NOTES
E1–5	Rabaul, New Britain	Views of Süd Tochter ['South Daughter'] volcano and crater	
E6	Rabaul	View of the 'Mother' volcano from Government House	
E7	Rabaul	View of Rabaul Harbour from Government House	
E8	Matape [Matupit] Island, Rabaul	General view of village	
E9	Matape Island	Making fish traps	Negative missing
E10	Matape Island	Lieutenant Peterson and pony	
E11	Matape Island	Group of children	
E12	Matape Island	Typical house	
E13–26	Herbertshöhe, New Britain	Dance scenes	
E27	Herbertshöhe	The Pavilion (14 pigs) and native fruit for dance	
E28	Herbertshöhe	Scene on coconut plantation	
E29, 30	Rabaul	Views of Rabaul from the Harbour	E30 also titled 'Japanese Town'
E31, 32	Herbertshöhe	Signalling station	
E33	Herbertshöhe	Native Police	
E34	Herbertshöhe	Street scene	
E35	Herbertshöhe	Governors Residence	
E36	Herbertshöhe	Young boys with toy boats	
E37	Herbertshöhe	Typical canoe	
E38	Witu Island, New Britain	Rubber plantation	
E39	Witu Island	Cocoa Plantation	
E40	Witu Island	Native labourers	
E41	Witu Island	Canoe making	
E42	Witu Island	Village scene	
E43	Witu Island	Coconut plantation	
E44	Witu Island	Witu Lagoon	
E45	Witu Island	Crew and Officers of the 'Meklong' cargo boat	
E46	Witu Island	Officers of the 'Meklong' cargo boat	
E47	Witu Island	E. S. Usher on 'Meklong' cargo boat	
E48	Witu Island	Witu Lagoon	
E49–53	Morobe, German New Guinea	Scenes at Morobe	E53 also titled 'Morobe Station'
E54	Morobe	Native men	
E55	Morobe	Native women	
E56, 57	Ablingi Island, New Britain	Women and babies	Shows head binding

E58	Ablingi Island	Man and child	
E59	Ablingi Island	Group of women	
E60	Ablingi Island	Women unloading canoes	
E61	Ablingi Island	Two men (portrait)	
E62	Ablingi Island	Men with shields	
E63	Lindenhafen, New Britain	Two men (portrait)	
E64	Lindenhafen	Man (portrait)	
E65	Lindenhafen	Group of men	
E66	Morobe	Group and village scene	

ALBUM F	LOCATION	USHER'S DESCRIPTION	INDEXER'S NOTES
F1–2	Vella Lavella Island, Solomons	Women (Liapari), side and front views	
F3	Vella Lavella Island	War canoes	
F4	Vella Lavella Island	General view	Also titled 'Plantation'
F5	Vella Lavella Island	Island King (portrait)	
F6	Vella Lavella Island	Two boys (portrait)	Also titled 'Natives'
F7	Vella Lavella Island	Malaita boy (portrait)	'Boy' = man
F8	Vella Lavella Island	Women (portrait)	
F9	Faisi, Shortland Island Solomons	Canoe scene	
F10, 11	Faisi, Shortland Island	General views	
F12–14	Simbo Is., Solomons	Tambo Shrine	
F15, 16	Simbo Island	General views, Simbo Lagoon	
F17	Simbo Island	Village scene	
F18, 19	Gizo Island, Solomon Islands	Views from Government Station	Panorama, left to right
F20	Russell Island, Solomon Islands	Native Church, Melanesian Mission	
F21	Vella Lavella Island	Canoe scene	
F22	Vella Lavella Island	Group of women	
F23	Helavo village, Gela Is.	Helavo village	
F24	Gela Island	Ivory nut trees	
F25	Helavo village, Gela Is.	Church	
F26	Tulagi, Solomons	View of Tulagi	
F27, 28	Tulagi	Views of Tulagi Harbour (Panorama)	right to left
F29	Guadalcanar, Solomons	Canoe scene	
F30	Simbo, Solomons	Canoe scene	
F31, 32	Rere, Guadalcanar	Women preparing yams	
F33	Rere, Guadalcanar	Man with [neck] growth (portrait)	
F34	Rere, Guadalcanar	Man (portrait)	
F35	Rere, Guadalcanar	Women	
F36, 37	Tasimboko village, Beraude, Guadalcanar	Houses	Negative F37 missing
F38	Tasimboko village	Women preparing yams	
F39–40	Tasimboko village	Village scenes	
F41	Toombosa village, Beraude, Guadalcanar	Church	
F42	Toombosa village	Village Scene	
F43	Guadalcanar	Coconut Plantation	
F44	Guadalcanar	Loading horses	
F45	Beraude, Guadalcanar	Lever Bros Plantation	
F46	Gela Island, Solomons	Village scene (Voloa)	

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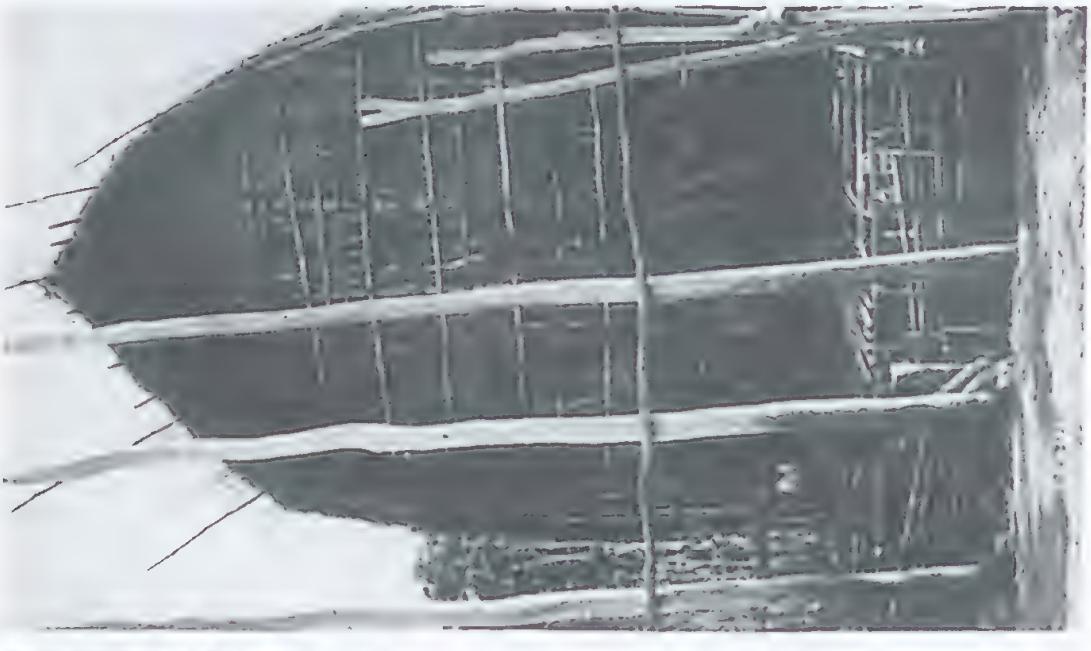
A11



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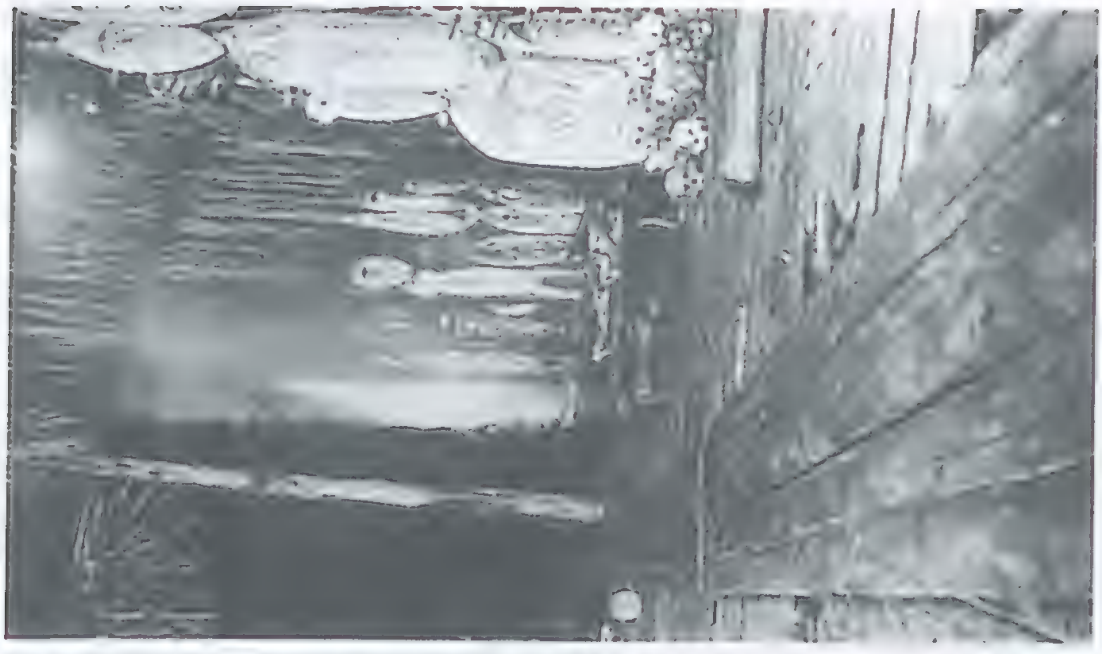

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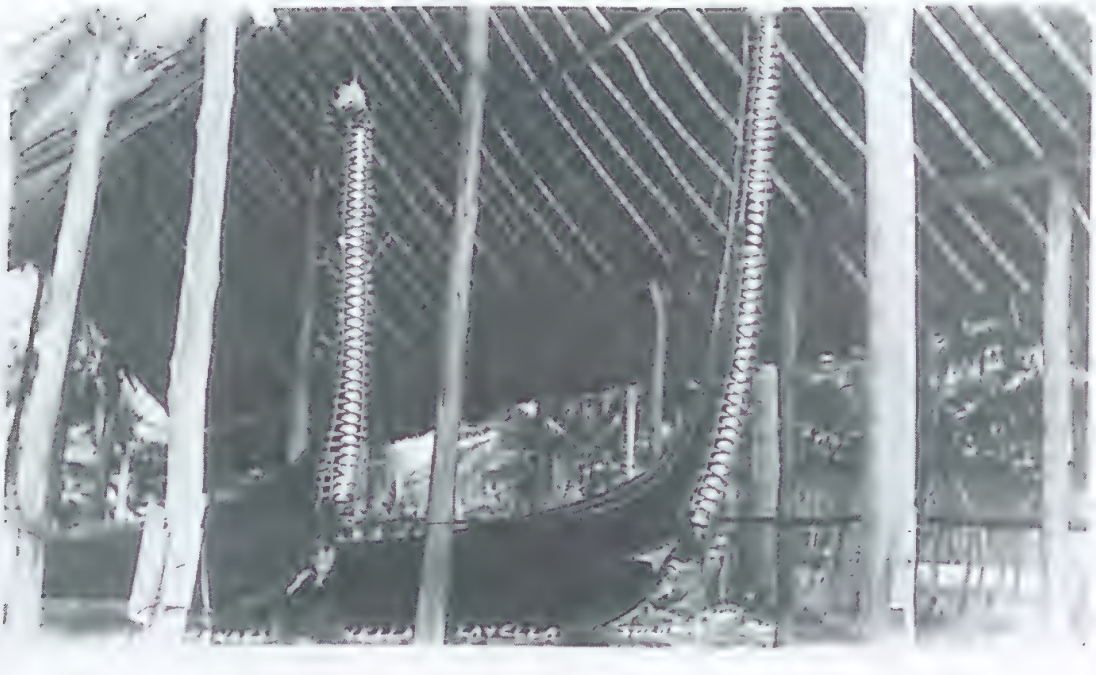

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Acknowledgments

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References

BLACKBURN, J. 1979. 'The White Men.' Orbis Publishing: London.

CRAIG, B. 1988. 'Art and Decoration of Central New Guinea.' Shire: Aylesbury, Bucks.

HADDON, A. C. & HORNELL, J. 1975. 'Canoes of Oceania.' Bishop Museum Press: Hawaii. (Volume 1, 1st ed 1936, Vol. 2, 1st ed 1937, Vol. 3, 1st ed 1938).

HOLMES, J. H. 1924. 'In Primitive New Guinea.' Seeley, Service & Co.: London.

MACKENZIE, S. S. 1938. 'The Official History of Australia in the War of 1914–1918, vol X: The Australians at Rabaul.' Angas & Robertson: Sydney.

MAMIYA, C. J. & SUMNIK, E. C. 1982. 'Hevehe: Art, Economics and Status in the Papuan Gulf.' Museum of Cultural History, UCLA: Los Angeles.

NEWTON, D. 1961. 'Art Styles of the Papuan Gulf.' Museum of Primitive Art: New York.

SELIGMAN, C. G. 1910. 'The Melanesians of British New Guinea.' University Press: Cambridge.

SPECHT, J. & Fields, J. 1984. 'Frank Hurley in Papua: Photographs of the 1920–1923 Expeditions.' Robert Brown: Bathurst, NSW.

WADE, A. 1915. 'Report on Petroleum in Papua.' Government Printer: Melbourne.

WILLIAMS, F. E. 1936. 'Bull-Roarers in the Papuan Gulf.' Anthropology Report No.17.Territory of Papua: Port Moresby.

WILLIAMS, F. E. 1940. 'Drama of Orokolo.' Oxford University Press: Oxford.

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CONTENTS PAGES

BARKER, S. 45–49
Designation of a lectotype and description of four new species of Australian Buprestidae (Coleoptera).

CLARKE, P. A. 51–67
Waiyungari and his relationship to the Aboriginal mythology of the Lower Murray, South Australia.

HENN, C. & CRAIG, B 69–89
The Pacific Cultures Gallery in the South Australian Museum.

HUTCHINSON, M. N. & DONNELLAN, S. C. 173–189
Genetic variation and taxonomy of the lizards assigned to *Ctenotus uber orientalis* Storr (Squamata: Scincidae) with description of a new species.

KEMPER, C. M. & SAMSON, C. R. 155–172
Southern right whale remains from 19th century whaling at Fowler Bay, South Australia.

LAWTON, R. S. 91–118
The chiefs of Kiriwina

OPRESKO, D. M. 143–154
New Species of *Antipathes* and *Parantipathes* (Cnidaria: Anthozoa: Antipatharia) from Coastal Waters of South Australia and Tasmania.

WATTS, C. H. S. 1–43
Revision of Australian *Hydrochus* (Coleoptera: Hydrochidae).

WATTS, C. H. S. 119
Rediscovery of *Enochrus peregrinus* in Australia (Coleoptera: Hydrophilidae)

WATTS, C. H. S. & HUMPHREYS, W. F. 121–142
Three new genera and five new species of Dytiscidae (Coleoptera) from underground waters in Australia.

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p.221, column 2 and p.224, column 2: alter D6 to D17;
p.249, photo numbers: alter D6 to D17 and D17 to D6.

MUSEUM VICTORIA

REVISION OF AUSTRALIAN *HYDROCHUS* (COLEOPTERA: HYDROCHIDAE)

C. H. S. WATTS

WATTS, C. H. S. 1999. Revision of Australian *Hydrochus* (Coleoptera: Hydrochidae). *Records of the South Australian Museum* **32**(1): 1–43.

The Australian members of the hydrochid genus *Hydrochus* are revised and redescribed. Ten species are described as new: *H. abditus, H. aenigmatis, H. atratus, H. burdekinensis, H. decorus, H. eurypleuron, H. cucullatus, H. macroaquilonius, H. numerosepunctatus* and *H. umbratilis*. The following synonymies are proposed: *H. adelaidae* Blackburn = *H. victoriae* Blackburn; *H. australis* Motschulsky = *H. brunneonitens* Lea = *H. diversiceps* Blackburn = *H. parallelus* MacLeay = *H. polaki* Makhan = *H. rambarani* Makhan = *H. regularis* Blackburn = *H. serricollis* Lea; *H. aschnakiranae* Makhan = *H. schillhammeri* Makhan; *H. horni* Blackburn = *H. scabricollis* Lea; *H. imamkhani* Makhan = *H. schoenmanni* Makhan; *H. multicolor* Lea = *H. matthewsi* Makhan; *H. obscuroaeneus* Fairmaire = *H. insularis* Lea = *H. palmerstoni* Blackburn = *H. rodjani* Makhan = *H. wewalkai* Makhan; and *H simplicicollis* Lea = *H. verae* Makhan. A key to the 25 Australian species recognised in the genus is given.

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Manuscript received 24 August 1998.

This is the first attempt to revise the Australian *Hydrochus* Leach since Lea (1927) tabulated the then known species and described several new ones. The genus is the only representative of the world-wide family Hydrochidae in Australia. It is taxonomically difficult. The species are numerous and characters few and variable. They fly readily to light which has resulted in large numbers of specimens being available to me, in contrast to earlier workers who had very sparse and inadequate material, often describing a species from a single individual. Despite this advantage, or perhaps because of it, I view this revision as very much a first attempt at making some taxonomic sense of the *Hydrochus* fauna of Australia, although I do not claim that there is much phylogenetic content to the work.

Individuals are often abundant in both still and running water in all areas of Australia where some surface water exists permanently, with the apparent exception of the channel country of south-west Queensland.

The collections from which specimens were examined are listed under the following abbreviations.

AM	Australian Museum, Sydney
ANIC	Australian National Insect Collection, Canberra
BPBM	Bishop Museum, Honolulu
BM(NH)	Natural History Museum, London
CAL	California Academy of Sciences, San Francisco
FIELD	Field Museum of Natural History, Chicago
CLH	Collection of Lars Heindrick, Berlin
DPIM	Queensland Department of Primary Industries, Mareeba
IRSNB	Institut Royal des Sciences Naturelles de Belgique, Bruxelles
MCZ	Museum of Comparative Zoology, Harvard University, Cambridge
NHMW	Naturhistorisches Museum, Vienna
NMV	Museum of Victoria, Melbourne
NTM	Northern Territory Museum, Darwin
QM	Queensland Museum, Brisbane
SAMA	South Australian Museum, Adelaide
UQIC	University of Queensland Insect Collection, Brisbane
WAM	Western Australian Museum, Perth
ZMM	Zoological Museum, Moscow

The early taxonomy of Australian *Hydrochus* (Blackburn 1898, Lea 1926) is based primarily on the strength of grooves on the head, foveae on the pronotum, and the relative strength of punctures on the elytra. Having examined over 6 000 specimens it is clear that these characters are very variable within species and of limited taxonomic worth.

Early authors were also hampered by the very limited amount of material available, often working with only one or two specimens at a time. Makhan (1994, 1995) added characters of the aedeagi but otherwise relied on this same range of characters and a very limited number of specimens.

Oliva (1995) working on South American species also concentrated on dorsal surface characters in conjunction with the male genitalia but in addition used leg colour and spines on the tibiae in a few cases. In Europe the strength of the apical punctures on the elytra have proved useful (Angus 1977).

Characters Used In This Revision

Size

Australian *Hydrochus* vary in length from under one millimetre to over four millimetres. Variation in length within species is considerable: up to two to three times in all those species where a good number and geographic spread of specimens are available.

Dorsal Surface

Head

I found no character of the head to be useful, other than the strength of the setae (see later) and of the Y- shaped epicranial suture to a very minor degree. Blackburn (1898), and Lea (1926) used the relative strength of three longitudinal grooves on the back of the head as a key character. I found the interspecific variation in this character, not to mention its subjective nature, too great for it to be used taxonomically.

Pronotum

Shape: Most Australian species have a similarly shaped pronotum and hence this character has been used sparingly.

Lateral edges: The degree of serration of the pronotal edges can range from none to considerable. This character is a direct reflection of the degree of granulation of the pronotum and has not been specifically used.

Epipleuron: In many *Hydrochus* species the lateral edge of the pronotum is bent under by almost ninety degrees. The width of this portion and its distinctness from the top of the pronotum varies considerably between species and species groups, yet variation within species appears to be only moderate.

Anterior edge: In one species (*H. cucullatus*) the front edge of the pronotum for nearly three quarters of its length is noticeably thickened and hence raised. In all other species this thickening does not occur.

Punctures and granulation: Many Australian species have well developed peg-like granules on the pronotum (and head and elytra). These are positioned in the areas between the punctures and are usually about half the diameter of a puncture. The punctures themselves are relatively large and usually close together. In many species the granulations, particularly on the head, appear as if they are worn down like teeth, and are very low with a smooth flat surface. When the granules are well developed they can completely mask the underlying punctures. The relative mix and strengths of punctures and granules can vary enormously within species. There are species which appear not to have granules and an occasional species (e.g. *H. umbratilis*) that seem always to be strongly granulate. In the bulk of species however the relative mix of punctures and granules is too variable to use as a taxonomic character.

Foveae: A number of relatively large, shallow, depressed areas are found in many species. The boundaries of these foveae may be outlined by raised areas which are sometimes further accentuated by being devoid of punctures or granules. Variation within species is considerable and is usually too great to allow the foveae to be used to separate species but they have a limited use in delineating species groups.

Elytra

Striae and interstriae: All *Hydrochus* have clearly defined linear striae which are punctate, separated by interstriae which are impunctate. As far as I can tell the number of striae and number of punctures in each stria do not vary between species. The strial punctures vary considerably within species as to size, which limits the use of this character taxonomically. In all species the diameter of the punctures is less at each end of a stria and in most cases is relatively uniform over the rest of the stria (and also between adjacent striae). In a few cases the punctures continue to increase in diameter towards the disc and occasionally vary between adjacent striae.

The interstrial areas can be smooth or granulate, with granules placed at the four corners of a puncture, which may have a somewhat squared rather than rounded shape. As on the pronotum, the strength and number of these granules can

vary from a few vestigial ones laterally to masking the punctures over the whole elytron. Again the large intraspecific variation limits the taxonomic usefulness of this character. Some interstrial areas are often raised, either partially or completely, and despite the usual large degree of variation, have proved of some taxonomic value.

Striae are numbered starting from the innermost stria. The first interstria is between striae one and two.

Plicae: In many *Hydrochus* there is a short raised portion of interstria eight just behind the middle. The degree to which the rest of interstria eight is raised and hence incorporates this structure is variable and is of some use in delineating species groups.

Apical punctures: A series of three to four punctures near the tip of each elytron are often differentially enlarged, and sometimes bounded behind by a raised area on the elytron. At the extreme tip there may be another one or two unusually large punctures. These punctures vary considerably between species and, unfortunately, also within most species.

Setae: Small, stout, pale setae are found on the elytra of a number of species. In most species, if present, they are restricted to the extreme apex of each elytron but in a few species they are also found on the interstriae over relatively large areas of the elytra. Similar setae are present in some species on the head and in one or two species on the pronotum as well.

Colour: The dorsal colour, particularly the presence/absence and pattern of elytral spots has proved a useful character. There is also a pronounced polymorphism in many species within my species group 2 where all or most of the dorsal surface can be either golden, silver, steely grey, testaceous or black within one species and often within one population.

Ventral Surface

Palpi and antennae

I have not made a detailed study of the antennae but I could find no obviously useful characters.

The form and colour of both the maxillary and labial palpi vary subtly between species. However I have been unable to usefully harness this variation, nor have I described it.

Legs

I have found the shape of the femora, the amount of pubescence at the base of the femora and the colour of the legs to be most useful characters to separate both species and species groups.

The profemora of most species are relatively similar in shape but vary in degree of basal pubescence. With the leg pointing forward, the pubescence is greatest on the upper surface next to the body. This surface is usually invisible with the leg in place and I have not used this character. On the lower surface the pubescence narrows to a thin band along the base of the femur adjacent to the trochanter. The area of the femur covered in this pubescence varies from none to quite a bit. In describing this I have compared the minimal length of the area covered (usually in the middle of the femur) with the width of the femur at that point. Within species variation is relatively moderate.

The mesofemora of different species vary considerably in both shape and amount of basal pubescence. Three main shapes are present: a relatively short, stout, parallel - sided form (Fig. 3); a little more elongate somewhat sinuate form with some narrowing towards the base (Fig. 4); and an elongate strongly spindle-shaped form greatly narrowed towards the base (Fig. 5). The amount of pubescence at the base also varies. With the leg pointed backwards the pubescence on the lower surface varies considerably between species but is relatively consistent within species. Usually the edge of the area of pubescence forms a C shape with the narrowest portion in the middle of the lower surface and the longest along the rear edge with a shorter portion along the front edge. The pubescence continues around the top surface of the leg but, as for the profemur, I have not described this surface since the variation is correlated with the variation on the more easily seen lower portion. In describing this character I have usually compared the distance the pubescence reaches along the rear edge of the femur with the width of the femur at that point.

The degree of pubescence and the shape of the femur are closely correlated. Thus strongly spindle-shaped mesofemora have little basal pubescence, stout mesofemora have a moderate amount, and the relatively robust sinuate mesofemora have a lot of pubescence.

There is some variation in the shape of the metafemora which tends to mirror that of the mesofemora. The upper side, with leg pointing backwards, has pubescence to a third to half of its length. The lower side lacks pubescence except

for a small amount coming round from the upper side to a slight degree in some species.

The colour of the legs has also proved useful. Most species have legs which are testaceous with the knees, apex of the tibiae, parts of the tarsi and often much of the femora darker. Other species have yellowish legs with only the tarsi with darker portions. Within most species the degree of dark and light areas is surprisingly consistent.

Elytra

In most beetles the lower edge of the elytron has a narrow shelf-like portion, the epipleuron, which is clearly differentiated from the top of the elytron and turns sharply under the beetle. In most Australian *Hydrochus* the epipleuron is broadened by a modification of the most lateral stria of the elytron which is also turned under to the same degree as the epipleuron (Figs 6–8). As a consequence the most lateral interstria (number 10) effectively becomes the edge of the elytron. Within Australian species the proportion of the underturned shelf formed by the true elytral epipleuron and what is termed the pseudoepipleuron formed from the elytron proper varies considerably between species but within species the relative widths of each do not vary greatly. When describing this character I have used isolated elytra since in the normal closed position the epipleuron is partially hidden in front. Towards the front of the epipleuron all species have a shallow groove along the inner edge which is part of the locking mechanism of the elytra. This varies little between species.

In about the middle of the elytron under interstria eight is a short robust shelf which locks with a raised structure on the thorax when the elytron is closed. This varies a bit in length and inclination but I have not been able to use this variation taxonomically.

Mesosternum

Like the rest of the ventral surface the mesosternum is strongly sculptured. At the front in the centre most species have two well - separated longitudinal carinae (Fig. 1). The area between them can be shallow or relatively deep and can have a weak '+' or 'T'-shaped structure within it. There is certainly a tendency for different species to have particular patterns of infill of this central region but not consistently enough to be taxonomically useful.

Three species have a distinctly different sculpture in this area. In these there are three even, well marked, longitudinal carinae (Fig. 2).

Metasternum

The pattern of punctures on the metasternal plates is very uniform across the Australian members of the genus. The basic pattern consists of 12 to 15 large, well separated punctures arranged in lose rows and arcs. There is a tendency, more marked in some species than in others, for some or most of the punctures to split into two without destroying the underlying standard pattern. In one species, *H. numerosepunctatus*, the metasternum (and mesosternum) is evenly covered with small to moderate punctures with no discernible trace of the basic pattern.

Abdominal sternites

These are strongly sculptured with raised front margins, a central longitudinal raised carina, and four large punctures and a further carina on each side. Although there is variation in the strength of this sculpture I have been unable to use it taxonomically.

Aedeagus

The variation in form of the aedeagus within Australian *Hydrochus* is not as extensive as that shown by *Hydrochus* in other areas (Makhan 1994, Oliva 1995) and differences between species are often slight. Nevertheless I have used it extensively in this revision. In many cases it proved the only reliable character to separate close species. The basal piece is usually parallel sided when viewed vertically but in a number of species it narrows toward the base and in others has a distinct twist. Viewed laterally the basal piece in most species is strongly curved upwards towards the base. The apical piece, consisting of lateral parameres and a central (or medial) lobe, is in all but a couple of species shorter than the basal piece. The central lobe varies considerably between species in width and in length compared to the parameres.

The aedeagi of all but one species, which is identical to another, are illustrated by drawings made with the help of a camera lucida. Where my concept of the species includes a range of aedeagus shapes the extremes are illustrated. Virtually all drawings were made with the apical piece closed up as in nature. In this configuration the central gap between the parameres is neatly filled by the central lobe. Ventral views are given in all cases, which I considered give a slightly better view of any development of the central lobe.

Types

The primary types, and most of the secondary types, were examined unless specifically stated otherwise. Blackburn and, to a lesser degree, Lea seldom clearly designated a holotype in their publications. They did however in most cases clearly mark a specimen with a 'T' or 'Ty'or with a TYPE label. In those cases were it is clear from the original description that there was more than one specimen before the author I have designated the specimen marked as a type by the author as the lectotype. In those cases where only one specimen appears to be involved and it is clearly labelled I have, of course, treated it as a holotype.

Key To Species Groups Of Australian *Hydrochus*

1. — Front of mesosternum in centre with three longitudinal carinae (Fig. 2.) ..... *Group 1*
   — Front of mesosternum in centre with two longitudinal carinae (Fig. 1) 2
2. — Elytra with dark spots (may be masked in dark specimens) (Figs 9–11). Mesofemur strongly to moderately spindle-shaped, at base < two thirds its greatest width (Fig. 5) ..... *Group 2*
   — Elytra without spots. Mesofemur cylindrical or weakly spindle-shaped, at base equal to or greater than two thirds its greatest width (Figs 3, 4) 3
3. — Mesofemur cylindrical or weakly spindle-shaped (Fig. 3). Basal pubescence on mesofemur seldom reaches much beyond apex of trochanter (Fig. 3); pubescence on ventral surface of profemur interrupted or reduced to a very narrow band (Fig.3) ..... *Group 3*
   — Mesofemur weakly spindle-shaped (Fig. 4). Basal pubescence on mesofemur usually reaches > one third of the width of femur at that spot along its posterior edge; basal pubescence on profemur complete, reaching > quarter width of femur along ventral surface (Fig. 4). ..... *Group 4*

Key To Species In Group 1

1. — Pronotum and elytra without granules, except weakly at apex and sides, often dull bronze/golden, elytra often with dark spots, a subscutellar one prominent; elytral apex constricted, squared off. Northern ..... *H. imamkhani* Makhan
   — Pronotum and elytra granulate, without dark spots, elytral apex rounded 2
2. — Elytral epipleuron as wide as pseudoepipleuron anteriorly, never with the elytral granules masking punctures ... . *H. adelaidae* Blackburn
   — Elytral epipleuron narrower than pseudoepipleuron, often hardly visible when elytra closed, never with weakly granulate, strongly punctate elytra .... *H. umbratilis* sp. nov.

Key To Species In Group 2

1. — Elytral epipleuron wide, pseudoepipleuron lacking, or virtually lacking, at least in front half (Fig. 8) 2
   — Elytral pseudoepipleuron well marked, a quarter width of epipleuron or more (Figs 6, 7) 3
2. — Dorsally dark brown to black, without elytral dark spots except very vague ones in some specimens. Base of parameres not narrower than top of basal piece of aedeagus (Fig.17) .... *H. eurypleuron* sp. nov.
   — Dorsally usually iridescent green/gold, elytral spots usually present, often well marked. Base of parameres may be narrower than top of basal piece of aedeagus ..... *H. decorus* sp. nov.
3. — Yellow legs, apart from darker areas on tarsi. May have black head and much lighter pronotum. Never have: strongly granulate elytra, moderate to strong apical punctures, strongly serrated elytron edge, length >3.4mm 7
   — Legs with darker areas, particularly knees and parts of femora and tarsi. May have strongly granulate elytra, strongly serrated elytron edge, moderate to strongly developed apical punctures, length >3.4mm. Never have: head (black) and pronotum a different colour unless teneral 4
4. — East coast south of Mackay. Aedeagus with short broad central lobe (Fig.18). Base of mesofemur narrowing to about

two thirds of its greatest width. Basal pubescence reaching well beyond end of trochanter. Length 2.5 –3.1mm. .... *H. aenigmatis* sp. nov.

— Northern. Aedeagus with longer central lobe (Figs 9–22). Base of mesofemur narrowing to about half of its greatest width. Basal pubescence not reaching beyond end of trochanter in middle of femur, except in *H. macroaquilonius* which is > 3.1mm in length 5

5. — Length < 2.5mm. Pronotal surface rugose to smooth but rather even with relatively shallow punctures and flat granules, apical piece of aedeagus triangular, central lobe narrow (Fig. 19), often with silver and black patches on pronotum .... *H. atratus* sp. nov. (in part)

— Length >2.0mm. Pronotal surface uneven, apical piece of aedeagus bullet shaped, central lobe wider (Figs 20–22), never with silver and dark patches on pronotum 6

6. — Length >3.1mm. Without or with very weak granules. Basal pubescence on mesofemur reaching beyond apex of trochanter in middle of femur. Legs with weak development of dark areas .... *H. macroaquilonius* sp. nov.

— Length < 3.5mm. Usually granulate, often quite strongly. Basal pubescence on meso femur seldom reaching beyond apex of trochanter in middle of femur. Legs usually with well developed dark regions ..... *H. interioris* Blackburn

7. — Front margin of pronotum in central half raised and thickened to about twice normal width. Elytral interstriae two and four often unevenly raised. Central lobe of aedeagus short. *H. cucullatus* sp. nov.

— Not as above 8

8. — Mesofemur proportionately narrower at base than metafemur. Anterior spot on elytron usually larger than others. Apical piece of aedeagus relatively small, may be narrower at base than top of basal piece (Figs 19, 24–27). 9

— Mesofemur and metafemur same general shape, although metafemur bit larger. Anterior sutural spot on elytron same size as others. Apical piece of aedeagus relatively longer, base of apical piece approximately same width as basal piece (Figs 28, 29) 11

9. — Length 0.9–2.4mm. Elytral epipleuron approximately half width of pseudoepipleuron in front half. Dorsal surface uniformly dark or with silver and dark patches on both elytra and pronotum. .... *H. atratus* sp.nov (in part)

— Length 1.6–3.3mm. Elytral epipleuron > half width of pseudoepipleuron in front half. Dorsal surface light to dark testaceous or green/gold (other than head which may be black), with darker spots on elytra 10

10. — Length 2.0–3.3mm. Ventral surface testaceous to black. Elytron, when spotted, with anterior sutural spot about same size as others (Fig. 11). Width of base of mesofemur equal to or greater than half its greatest width. Base of apical piece of aedeagus not narrower than top of basal piece (Fig. 24) .... *H. burdekinensis* sp. nov.

— Length 1.6–2.5mm. Ventral surface black; head and pronotum often greenish, elytra often testaceous/golden/greenish with anterior sutural spot on each elytron usually much larger than others (Figs 9,10). Mesofemur strongly spindle-shaped with its basal width equal to or less than its greatest width. Base of apical piece of aedeagus narrower than top of basal piece, tendency for the central lobe to bulge out above parameres (Figs 25–27). .... *H. lateviridis* Blackburn

11. — Apical piece of aedeagus relatively longer (basal piece 1.0–1.4 times length of apical piece) (Fig. 28). Northern .... *H. simplicicollis* Lea

— Apical piece of aedeagus relatively shorter (basal piece 1.5–2.0 times length of apical piece) (Fig. 29). Southern .... *H. obsoletus* Lea

Key To Species In Group 3

1. — Punctures in inner elytral striae continue to enlarge towards middle of elytra after about puncture four from the base. Northern species 2

— Punctures in inner elytral striae do not

increase much in size after about puncture four from base. If northern, < 2.6mm long 3

2. — Length > 3.2 mm. Mesosternum evenly covered with deep, relatively small punctures. .... *H. numerosepunctatus* sp. nov

— Length < 2.8mm. Mesosternum usually normally sculptured (relatively few rather large punctures unevenly distributed) .... *H. obscuroaeneus* Fairmaire

3. — Pronotum rugose to smoothly sculptured, seldom granulate on disc (mainly central Australian specimens). Area of pubescence at base of mesofemur approximately the same area as that of trochanter. Knees dark. Usually have: pinched elytral apex, weak apical punctures, pronotum with bare areas 4

— Pronotum granulate, lacking smooth areas. Area of pubescence at base of mesosternum < area of trochanter. Knees no darker than rest of legs. Apex of elytra rounded with strong apical punctures. N.S.W. ..... *H. granicollis* Lea

4. — Length 1.8–2.3mm. Pronotal epipleura weak to absent. Central lobe of aedeagus with broad tip (Fig. 34. Northern (Cape York and Arnhem Land)) .... *H. gitaraiae* Makhan

— Length 2.0–3.4mm. Pronotal epipleura moderate, but often ill-defined. Central lobe of aedeagus with narrow tip (Figs 35, 36). Southern, rarely in North Queensland. ..... *H. horni* Blackburn

Key To Species In Group 4

1. — Elytral interstria two raised for short distance near base, interstria four raised in central portion of elytron ending abruptly behind middle (occasional specimens have only weakly raised interstriae). Aedeagus with basal piece 1.7–1.9 times length of apical piece, which is narrowly triangular and sharply pointed (Fig. 40) ..... *H. multicolor* Lea

— Elytral interstriae if raised then evenly and relatively weakly. Aedeagus with proportionately much longer apical piece (Figs 38, 39, 41–44) 2

2. — Aedeagus with apical piece elongate, bases of parameres usually bulbous, parameres rapidly narrowing in middle, apical half thin, sometimes twisted; central lobe thin; basal piece not twisted. Elytral epipleuron equal to or greater than width of pseudoepipleuron in front half. Basal pubescence on ventral surface of mesofemur reaches a distance equal to or greater than half width of femur along hind edge. Pronotal epipleuron weak or absent. Often quite light to moderately testaceous dorsally .... *H. australis* Motschulsky

— Aedeagus not with above combination of characters. Elytral epipleuron equal to or less than pseudoepipleuron in width in front half. Basal pubescence on mesofemur reaches a distance equal to or less than half width of femur along hind edge. Pronotal epipleuron usually moderately developed. Black dorsally .. 3

3. — Aedeagus with base twisted, central lobe narrow with tip twisted to left (viewed ventrally), parameres weakly asymmetric to accommodate off-centre central lobe tip, parameres narrow towards tips (Fig. 38) ..... *H. aschnakinarae* Makhan

— Aedeagus with base with at most only a hint of a twist, central lobe moderately wide, parameres symmetric (Figs 39, 43, 44) 4

4. — Aedeagus with parameres narrowing rapidly in middle, narrow and even in width in apical half, central lobe wide (Fig. 43) ..... *H. abditus* sp. nov.

— Aedeagus with parameres relatively wide, tips paddle-shaped, may be waisted (Figs 39, 44) 5

5. — Aedeagus with apical piece squat, parameres bulbous at base, apical piece approximately twice as long as wide, basal piece narrowing towards base (Fig. 39) ..... *H. kunarajahi* Makhan

— Aedeagus with apical piece more elongate, apical piece > twice as long as wide (Fig. 44) ..... *H. radjiei* Makhan

Descriptions

In the following sections the descriptions of species are arranged alphabetically within each of the four species groups.

Species Group 1

A group of three relatively large species characterised by having three rather than two longitudinal carinae at the front of the mesosternum and stout broad aedeagi. The two southern species, *H. adelaidae* and *H. umbratilis*, are very similar and seem distinct from the northern *H. imamkhani* which is the only Australian species with spotted elytra other than group 2 species.

The two southern species are found at the sides of poorly vegetated, often deeply shaded, pools most frequently among dead leaves and other detritus. *Hydrochus imamkhani* is found in more open areas amongst emergent vegetation in still or slow moving water.

Hydrochus roepnaraini Makhan from New Caledonia belongs in this group.

Hydrochus adelaidae Blackburn

Hydrochus adelaidae Blackburn, 1888 p. 832

= *Hydrochus victoriae* Blackburn, 1888 p. 834; syn. nov.

Types

Hydrochus adelaidae Blackburn. *Holotype*: 'T 1618 ?A' 'Australia Blackburn Coll. B.M. 1910–236' 'Hydrochus Adelaidae', BMNH. Blackburn (1888) gives the type locality as 'River Torrens near Adelaide'.

Hydrochus victoriae Blackburn. *Lectotype*: 'Type' 'T 1551 V' 'Australia Blackburn Coll. BM. 1910–236' 'Hydrochus victoriae Blackb.', BMNH. Herein designated. Blackburn (1888) gives the type locality as 'Ararat Victoria'.

Paralectotype: 1, '1551V' 'Victoria Blackburn' 'Hydrochus victoriae Blackb. Co-type' SAMA. Herein designated.

Description (number of specimens examined, 42)

Size 2.5 to 3.7mm. Broadly elongate, elytra wider than pronotum, widest just behind middle, apex rounded. Head black; pronotum black, often with vague testaceous front margin; elytra testaceous to dark testaceous; ventral surface dark testaceous to black; legs light testaceous lacking darker knees. Head with large granules, epicranial suture weakly to moderately marked. Pronotum weakly waisted, densely covered with granules, which mask punctures; foveae virtually absent; epipleuron distinct, about one puncture width wide. Elytra without granules to moderately granulate, punctures relatively large often increasing in size considerably towards centre of elytra within a stria, interstria four tends to be raised particularly just behind middle, plica indistinct, apical punctures weak. Setae on head and towards apex of elytra weakly developed. Front of mesosternum in centre with three longitudinal carinae, the distance between them greater than their widths. Pseudoepipleuron moderately developed, epipleuron weakly developed in apical half, quite strongly developed in anterior half where it is approximately same width as pseudoepipleuron. Profemur moderately stout, basal pubescence moderate, about a quarter width of femur at base. Mesofemur elongate, narrowing to about two thirds greatest width towards base, basal pubescence well developed reaching to about a half width of base of femur beyond trochanter on ventral rear margin. Metafemur elongate, bowed on front margin.

Male: Basal piece of aedeagus broad, subparallel, 1.4 to 1.8 times length of apical piece. Parameres wide in basal half, narrowing towards tip. Central lobe relatively narrow, sharply pointed, reaching to end of parameres. Similar to that of *H. umbratilis*, Fig. 14.

Distribution

South Australia
Williamstown, SAMA.

Tasmania
Launceston, SAMA.

Victoria
Buangor, SAMA; 5 km NW Portland, SAMA.

Remarks

This species appears close to *H. umbratilis* but the strongly punctate and usually granule-free elytra readily tell them apart. For those specimens with more strongly granulate elytra (usually with weaker punctures also) the wider elytral epipleura will separate them. The elytra are often lighter in colour than the pronotum which seldom is the case in *H. umbratilis*. The parameres appear to narrow a little less abruptly in this species but the aedeagi are otherwise very similar. The pronotal epipleura are a little narrower than in *H. umbratilis*. *Hydrochus australis* is superficially similar, particularly strongly granulate specimens, but the front of the mesosternum, and the very different aedeagi readily separate them. Nor do *H.*

australis have the large elytral punctures seen in most *H. adelaidae*.

Biology

The species is most often found amongst dead leaves at the edges of ponds, which are often shaded and poorly vegetated.

Hydrochus imamkhani Makhan

Hydrochus imamkhani Makhan, 1994

Type

Holotype: 'New Guinea; SE Weam, 9m 18.VI.1964' 'H. Clissold Light Trap BISHOP MUSEUM', BPBM.

Description (number of specimens examined, 94) Figs 2, 12, 13

Length 2.8 – 4.4mm. Elongate, elytra weakly to moderately broadened behind middle, narrowing quite abruptly near apex, obliquely truncate. Head dark brown to black, with iridescent sheen; pronotum dark brown, front margin sometimes lighter, often shiny iridescent green/gold; elytra dark brown to a shiny green/gold/silver surface, frequently with dark spots/markings, one of the more prominent around scutellum; ventral surface dark brown to black, legs light testaceous with parts of tarsi and knees darker. Head granulate/punctate, epicranial suture weak. Pronotum rugose/punctate, punctures relatively small, sides may be weakly to moderately granulate, foveae weak, not bounded by raised areas, tendency for central third longitudinally to be raised, epipleuron well marked, one to two punctures deep, often fluted. Elytra usually rather smooth with small to medium, even-sized punctures, not granulate or with relatively weak granules at sides and apex; without apical punctures, interstriae variable from almost unraised to quite strongly swollen, in the latter case alternate interstriae unevenly raised with interstria four having a more prominent portion at start of elytral declivity, interstriae in dark areas not swollen and may even be slightly sunken, in some specimens some other striae weakly raised in places also; plica usually recognisable but incorporated into interstria eight if raised. Setae small but well developed on head and towards rear of elytra. Pronotal epipleuron distinct, two to three puncture widths deep, often fluted. Pseudoepipleuron moderately to quite well developed; epipleuron absent towards rear, weak in front, ridge between pseudoepipleuron and epipleuron strong. Profemur moderately elongate, weakly sinuate, basal pubescence weak, reduced to a very narrow band ventrally < quarter width of femur. Mesofemur elongate narrowing in basal third to about two-thirds its greatest width, basal pubescence moderate, reaching between a fifth and a third of width of femur at that point along rear margin beyond end of trochanter. Metafemur elongate, front edge weakly bowed. Front of mesosternum in middle with three broad longitudinal carinae, the lateral two usually broader than central one, area between carinae much narrower than carinae, behind these are a row of four round punctures. Metasternal punctures smaller and more numerous than in most other Australian species.

Male: Basal piece of aedeagus broad, subparallel, 1.5–1.6 times length of apical piece. Apical piece bullet-shaped, parameres broad in basal half thin in apical quarter; central lobe relatively broad, sharply pointed, tip bent downwards, reaching to ends of parameres. Fig. 12.

Distribution

Northern Territory

Berry Springs, ANIC; Florence Falls, Litchfield NP, NHMW, CLH; Holmes Jungle, ANIC; Howard Springs, ANIC; Katherine, ANIC; Lake Bennett, NTM; Jabiru, SAMA; 10 km SW Jabiru, SAMA; 20 km SSW Jabiru, SAMA; Jim Jim Highway, Kakadu NP, CLH, NHMW; Jim Jim Falls, Kakadu NP, NHMW; 19 km E by S Mt Borradaile, ANIC; Murganella, NTM.

Queensland

8 km N Bluewater, SAMA; Cape Flattery area, DPIM; Dalby, SAMA; Dalhunty River, SAMA; Eubenargee Swamp, SAMA; 70 km SW Greenvale, SAMA; Iron Range, ANIC, UQIC; Jardine River, UQIC; Lockerbie, UQIC; Mareeba, NHMW; 21 km E Mareeba, DPIM; Mary Creek., ANIC; 8 km E Mt Cahill; 2 km S Mt Molloy, SAMA; 2 km N Mt Molloy, SAMA; 6 km ENE Mt Tozer, ANIC; 11 km ENE Mt Tozer, ANIC; 3 km NE Mt Tozer, ANIC; 2 km NNE Mt Tozer, ANIC; 3 km NE Mt Webb, ANIC; ANIC; Peach Creek, SAMA; 5 km W by W Rounded Hill, ANIC; Tolga, DPIM.

Western Australia

Carson Escarpment, ANIC; Drysdale River, ANIC; 12 km S Kalumburu Mission, ANIC; Mitchell Plateau, SAMA, ANIC; Peron Peninsula, WAM; Regans Ford, ANIC.

Remarks

A large, distinctive, isolated species unlikely to be confused with any other Australian species. *Hydrochus roepnaraini* Makhan from New Caledonia appears to be close. Based only on the type specimen, *H. roepnaraini* has a similar mesosternal front and similar dorsal colour and sculpture to those *H. imamkhani* which have most elytral interstriae raised to some degrees in some places. The aedeagi are quite different with *H. roepnaraini* having a much longer apical piece (see fig. 26 in Makhan 1994).

Hydrochus imamkhani was described from New Guinea but an examination of the type shows that it is conspecific with Australian specimens. Makhan (1994) thought it was similar to *H. rodjani* but this species is a junior synonym of *H. obscuroaeneus,* a very different species from *H. imamkhani.*

I have seen two specimens of *H. umbratilis* from near Cardwell in North Queensland. Their dark colour, lack of elytral spots, strongly granulate pronotum and stouter legs separate them from *H. imamkhani.*

Biology

Most frequently found amongst emergent vegetation in ponds, swamps or slowly moving water. Taken at light.

Hydrochus umbratilis sp. nov.

Types

Holotype: Male, 'VIC 10 km NE Mirranatwa 12/10/97 C. Watts', SAMA.

Paratypes: 35, same data as holotype, SAMA.

Description (number of specimens examined, 93) Fig. 14

Length 2.1 – 4.7mm. Broadly elongate, elytra widened somewhat behind middle, apex rounded. Dorsal surface testaceous to black; ventral surface dark brown, legs testaceous, parts of tarsi, knees and femora often darker. Head granulate, epicranial suture weak to moderate. Pronotum moderately to densely granulate, foveae virtually absent. Elytra moderately to very strongly granulate, punctures when visible small to moderate, alternate elytral interstriae weakly to strongly raised with interstria four often strongest; plica absorbed into interstria eight. Setae well developed on head and apical half of elytra. Pronotal epipleuron distinct, about one and a half puncture widths deep, often fluted. Front of mesosternum in centre with three longitudinal carinae, lateral ones about same width as central, area between them about equal to their width, tendency in some populations for this area to become relatively smooth and the carinae indistinct. Mesosternal punctures tending to be smaller and more numerous than usual. Pseudoepipleura moderately to quite strongly developed, epipleura absent behind, weak in front. Profemur moderately stout, basal pubescence relatively weak, reduced to very narrow band ventrally. Mesofemur elongate, narrowing a bit toward base, basal pubescence weak to moderate, at weakest reaching to end of trochanter at strongest reaching to about a quarter the width of base of femur beyond trochanter on ventral rear margin. Metafemur elongate, bowed on front margin.

Male: Basal piece of aedeagus broad, subparallel, 1.4 – 1.8 times length of apical piece. Parameres wide in basal half, rapidly narrowing, thin apically. Central lobe relatively narrow, sharply pointed, reaching to end of parameres (Fig. 14).

Distribution

Australian Capital Territory

25 km W Canberra, ANIC.

New South Wales

Armadale, ANIC; Berry, SAMA; Collector, SAMA; 14 km W Delagate, SAMA; Nerriga, SAMA; 6 km N Uralla, ANIC.

Queensland

Caloundra, SAMA; Cardwell, ANIC; 10 km S Cardwell, SAMA; Cunninghams Gap, SAMA

Tasmania

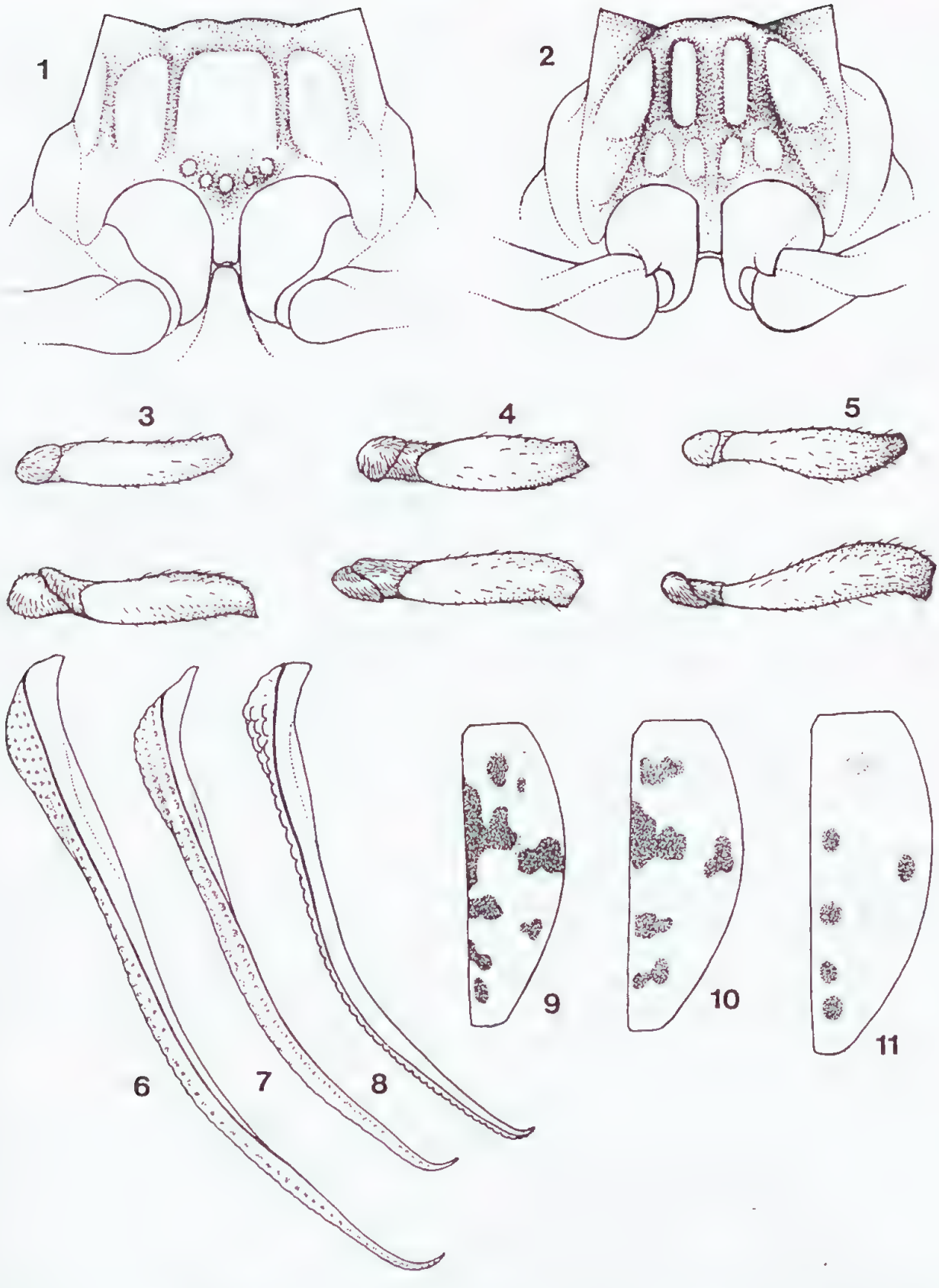
Launceston, SAMA; 5 km W Maydena, NHMW

Victoria

Buangor, SAMA; Eustace Gap Creek, NMV; Glenferrie, CAL; Grampians, SAMA; 18 km NW Licola, NMV; 10 km NE Mirranatwa, SAMA; 4 ml NE Nelson, NMV; 12 km SW Orbost, SAMA; 5 km NW Portland, SAMA; 3 km SE Taggerty, NMV.

Remarks

This species and *H. adelaidae* are the only species in southern Australia with three longitudinal carinae at the front of the mesosternum. The narrower elytral epipleura in this species is the only certain character to separate the two. However, *H. adelaidae* never



FIGURES 1–11. **1**, Front of mesosternum of *H. burdekinensis*, with two longitudinal carinae; **2**, Ditto of *H. imamkhani*, with three longitudinal carinae; **3**, Pro(top) and meso femora (below) of *H. obscuroaeneus*, a group 3 species; **4**, Ditto, *H. aschnakiranae*, a group 4 species; **5**, Ditto, *H. interioris*, a group 2 species; **6**, Ventral view of elytron edge in *H. australis* showing epipleuron (right) and pseudoepipleuron (left) of approximately equal widths; **7**, Ditto, *H. aschnakiranae* showing weaker epipleuron; **8**, Ditto, *H. eurypleuron* showing wide epipleuron and virtual lack of pseudoepipleuron; **9–10**, Dorsal views of elytra showing variants of the colour pattern in *H. lateviridis*; **11**, Ditto, *H. burdekinensis*.

have strongly granulate elytra and *H. umbratilis* never have elytra with large punctures which often increase in size towards the middle of the elytra within one stria (this character is best viewed when the specimen is dry since when wet the appearance of granules is enhanced). The three longitudinal carinae, and the weak elytral epipleura will separate it from strongly granulate forms of *H. australis*. It is also a wider and darker species than *H. australis* with stronger pronotal epipleura. It shares with *H. imamkhani* the three carinae on the front of the mesosternum and also a tendency for the mesosternal punctation to be composed of numerous rather small punctures. The aedeagi are also very similar but the apical piece is shorter and the central lobe narrower than in *H. imamkhani*. It can be separated from this species most readily by its strongly granulate dorsal surface, dark colour and rounded elytral apex.

Specimens from north coastal NSW to north Queensland are often chunkier with stouter legs, the alternate elytral interstriae more strongly raised and the elytral granulations usually weaker. Further specimens and study could well result in them being considered a separate species.

Biology -

Found in dead leaves at the sides of still or slowly moving water, often in shaded situations.

Etymology

Latin. 'of the shade'– in reference to its dark colour and the fact that it is often found in deeply shaded ponds.

Species Group 2

The largest of the groups in terms of species, group 2 is characterised by having: two rather than three longitudinal carinae at the front of the mesosternum (Fig. 1); dark spots on the elytra which are often coloured in some way (Figs 9–11); thin spindle-shaped legs with weak basal pubescence (Fig. 5). All species have the elytral spotting to a greater or lesser degree but not all individuals. The only other Australian *Hydrochus* with similar markings is *H. imamkhani* in group 1. Other character states that tend to distinguish the group are: lack of, or virtually lack of, setae on the dorsal surface; pubescence on the mesofemora usually not reaching much past the end of the trochanter; pubescence on the profemora complete but narrow ventrally (Fig. 5); pronotum either lacks or has very weak foveae; pronotal epipleura usually well marked; head with only a weak development of the epicranial suture; elytra usually smooth or with only weakly raised interstriae (in one species, *H cucullatus*, they may be strongly raised) and the plicae are usually obvious.

All member species whose habitat is known live in relatively clean sand/gravel at the sides of rivers and streams. They are typically found in large numbers at the edges of sandy pools in the beds of drying rivers in tropical Australia where they are often concentrated just below the surface of the sand. All species in this group that I have observed, when dislodged, put their heads down and attempt, albeit weakly, to swim to the bottom, in contrast to species of other groups which use the surface film to crawl upside down until they reach the side or emergent objects or vegetation. They also appear more adept at clinging to sand grains etc. on the bottom than species in other groups. This is often seen in collecting trays where group 2 species tend to be on the bottom of the tray and species of other groups tend to float on the surface .

The group is primarily tropical with only *H. obsoletus* commonly found in southern Australia.

Hydrochus aenigmatis sp. nov.

Types

Holotype: male, 'Webers ck NSW 2/11/94', SAMA.

Paratypes: 4, same data as holotype, SAMA; 1, 'Megalong Vy. Blue Mts N.S.W. Jan 20`32,1000ft' 'Australia Harvard Esp. Darlington', MCZ; 1, '21 ml. S of Miriam Vale Q 24°38S 151°34E 14.xii.1968 E. Britton & S. Misko', ANIC.

Description (number of specimens examined, 10) Fig. 18

Length 2.5 – 3.1mm. Elongate, elytra a little wider in the middle, tip rounded or weakly obliquely truncate. Head and pronotum dark steely-grey often with silver reflections; elytra dull brown to steely-grey, three to four rather small dark spots near suture, usually indistinct, about equal in size; ventral surface dark brown to black, legs testaceous, parts of tarsi, knees and basal part of femora darker. Head shallowly and rather smoothly granulate/punctate, epicranial suture weak. Pronotum with rather sparse, small shallow punctures, occasionally weakly granulate laterally,

surface uneven, foveae indistinct. Elytra with relatively small punctures, separated within striae by about same width as interstriae or a bit less; alternate interstriae not or only weakly raised; plica present; apical punctures usually well developed. Setae virtually absent from head and elytra. Pronotal epipleuron poorly defined, about two puncture widths wide, weakly fluted. Elytral pseudoepipleuron moderate, epipleuron absent apically, weak behind middle, widening to about same width as pseudoepipleuron in front. Front of mesosternum in centre with two narrow, raised, longitudinal carinae, the area between them shallow to moderately deep, particularly behind. Profemur rather stout, basal pubescence weak, reduced to a narrow band ventrally. Mesofemur elongate, weakly spindle-shaped, narrowing basally to about two thirds its greatest width, basal pubescence moderate, reaching to between a quarter and a half width of femur past trochanter on ventral edge. Metafemur elongate, bowed on front edge narrowing to about three quarters its greatest width basally.

Male: Basal piece of aedeagus straight sided, 1.5 to 1.7 times length of apical piece. Apical piece bullet-shaped, parameres narrow and weakly paddle-shaped in apical half. Central lobe very wide, considerably shorter than parameres; in lateral view ventral surface flat, width rapidly reducing in middle (Fig.18).

Distribution

New South Wales

Megalong Valley, MCZ; Webers Creek, SAMA.

Queensland

15 km W Gympie, NMV; 21 ml S Miriam Vale, ANIC.

Remarks

A rare species from the east coast, separable from other group 2 species with dark legs by its relative lack of granules, stouter legs and more extensive basal pubescence on the mesofemora. It can be confused most readily with the much commoner *H. interioris*, from which it differs in having stouter mesofemora with a greater amount of basal pubescence, and a broader central lobe to the aedeagus. Based on the few specimens known, *H. aenigmatis* also appears to be a more southern species than *H. interioris*.

In size and general colour *H. aenigmatis* approaches *H. obsoletus*, the only other group 2 species in the South-east. It differs from this species in the stronger basal pubescence on the mesofemur, which reaches more than a quarter the width of the femur past the trochanter whereas in *H. obsoletus* it usually is only a bit beyond the end of the trochanter; in the dark areas on the legs; in the rougher pronotal surface; narrow less distinct pronotal epipleura and in having the pronotum the same colour as the head whereas in *H. obsoletus* the head is often darker. The male genitalia approach those of *H. obsoletus* but have a much broader central lobe and, in lateral view, the apical piece is flat dorsally and narrows abruptly in the middle ventrally, in contrast to the more evenly narrowing shape in *H. obsoletus*.

Biology

Nothing known

Etymology

Latin. 'Obscure'– a reference to its rarity.

Hydrochus atratus sp.nov.

Types

Holotype: male, 'Qld. Burdekin r. E of Charters Towers 4 May 1998 C.H.S. Watts', SAMA.

Paratypes: 16 same data as holotype, SAMA.

Description (number of specimens examined, 221) Fig. 19

Length 0.9 – 2.4mm. Elongate, elytra wider behind middle, rounded or somewhat pinched near apex. Head shiny black; pronotum shiny black, granules if present often silver; elytra dark brown to black with vague darker spots in some, occasionally quite silvery; ventral surface dark brown to black, legs light to quite dark testaceous, parts of tarsi, knees and femora usually darker. Head granulate/punctate often with bare areas, epicranial suture weak to moderate. Pronotum variable, from strongly granulate/punctate to dense, rugose, rather large punctures, foveae absent. Elytra variably granulate/punctate, punctures moderate sized, within striae separated by about width of interstriae. Interstriae four and eight may be weakly raised in parts, plicae visible. Setae on head and elytra absent. Pronotal epipleuron poorly to moderately defined but relatively deep. Front of mesosternum in middle with two narrow longitudinal carinae, area between them quite deeply excavated in front, less so behind. Elytral pseudoepipleuron moderate to broad, epipleuron absent behind increasing to equal to width of pseudoepipleuron or a little less

in front third. Profemur elongate, basal pubescence moderate, reaching to about a quarter width of femur ventrally. Mesofemur spindle-shaped, narrowing to more than half its greatest width in basal quarter, basal pubescence weak, reduced to a very narrow band ventrally. Metafemur rather broad, bowed on front edge, narrowing to nearly half its greatest width toward base.

Male: Basal piece of aedeagus with parallel sides or weakly converging toward base, 1.8 – 2.1 times length of apical piece. Apical piece moderately to strongly elongate triangular, in more elongate forms with constriction in middle. Central lobe narrow, nearly as long as parameres (Fig. 19).

Distribution

Northern Territory

Adelaide River, ANIC; Cooper Creek near Mt Borradaile, SAMA; 20 km SSW Jabiru, SAMA; Kongarra, NTM; Korlonjorlok Stream, Kakadu NP, NTM; 6 km E Mt Cahill, NTM; 8 km E Mt Cahill, ANIC; 19 km E by S Mt Borradaile, ANIC; 5 km SE Mt Borradaile Station, SAMA; 11 km S by W Nimbuwah Rock, NTM; 6 km SW by S Oenpelli, ANIC; UDP Falls, Kakadu NP, NTM; Woolwonga Fauna Reserve, ANIC.

Queensland

Archer River, SAMA; Borumba Dam, CLH, NHMW; Burdekin River, SAMA; Burdekin River E of Charters Towers, SAMA; Dalrymple, 30 km N Charters Towers, NHMW; 70 km SW Greenvale, SAMA; 2 km S Mt Molloy, SAMA; Starr River, SAMA.

Western Australia

Augustus Island, ANIC; Drysdale River, ANIC; 12 km S Kalumburu Mission, ANIC; 14 km S by E Kalumburu Mission, ANIC; 4 km W King Cascade, ANIC; Kunmunya Mission, ANIC; 4 km S by W Mining Camp Mitchell Plateau (15.38S 125.15E), ANIC; 10 km NW by N Mining Camp Mitchell Plateau, ANIC; Point d'Entrecasteaux, WAM.

Remarks

Specimens of the species are the smallest Australian *Hydrochus*, with Northern Territory and Kimberley specimens often less than a millimetre long. In certain parts of their range they can reach 2.5mm which overlaps the size range of the very similar *H. interioris*. *Hydrochus interioris* is larger, the pronotal surface is very uneven and the apical punctures on the elytra are often well developed whereas in *H. atratus* the pronotal surface (ignoring the punctures) is relatively smooth and the apical punctures seldom larger than adjacent punctures. Small individuals of *H. interioris* are difficult to separate from *H. atratus* other than by the aedeagus. In general *H. atratus* are darker, without elytral spots, rounded more than elongate and may have dark shadows on the pronotum. The aedeagus in *H. atratus* has a more triangular shaped apical piece and narrower central lobe.

Hydrochus atratus is easily separated from well coloured individuals of *H. lateviridis* but larger specimens can be very similar to dark specimens of *H. lateviridis*. From *H. lateviridis* it differs in the narrower elytral epipleura, in often having dark portions to its legs, in the stouter meso and metafemora which narrow to between two thirds and half their greatest widths basically, rather than to more than half in *H. lateviridis*, and in the pronotum and head of *H. lateviridis* often having a greenish tinge absent in *H. atratus*. *Hydrochus atratus* often has, uniquely in Australian *Hydrochus*, dark and light areas on the pronotum. The aedeagi of some *H. atratus* resemble those of some *H. lateviridis* but in *H. lateviridis* the central lobe is more exposed and bulbous, the base of the apical piece is always narrower than the basal piece and the aedeagus may be twisted (Figs 25 – 27).

Four specimens from Kunmunya Mission, WA, in ANIC belong to this species or possibly a new one. They differ in having broader pseudoepipleura, a more uneven pronotal surface and a narrower, waisted apical piece to the aedeagus.

Biology

Found most commonly in bare coarse sand at the edge of small pools beside seasonally drying large rivers. In such places they can be extremely abundant. Taken at light.

Etymology

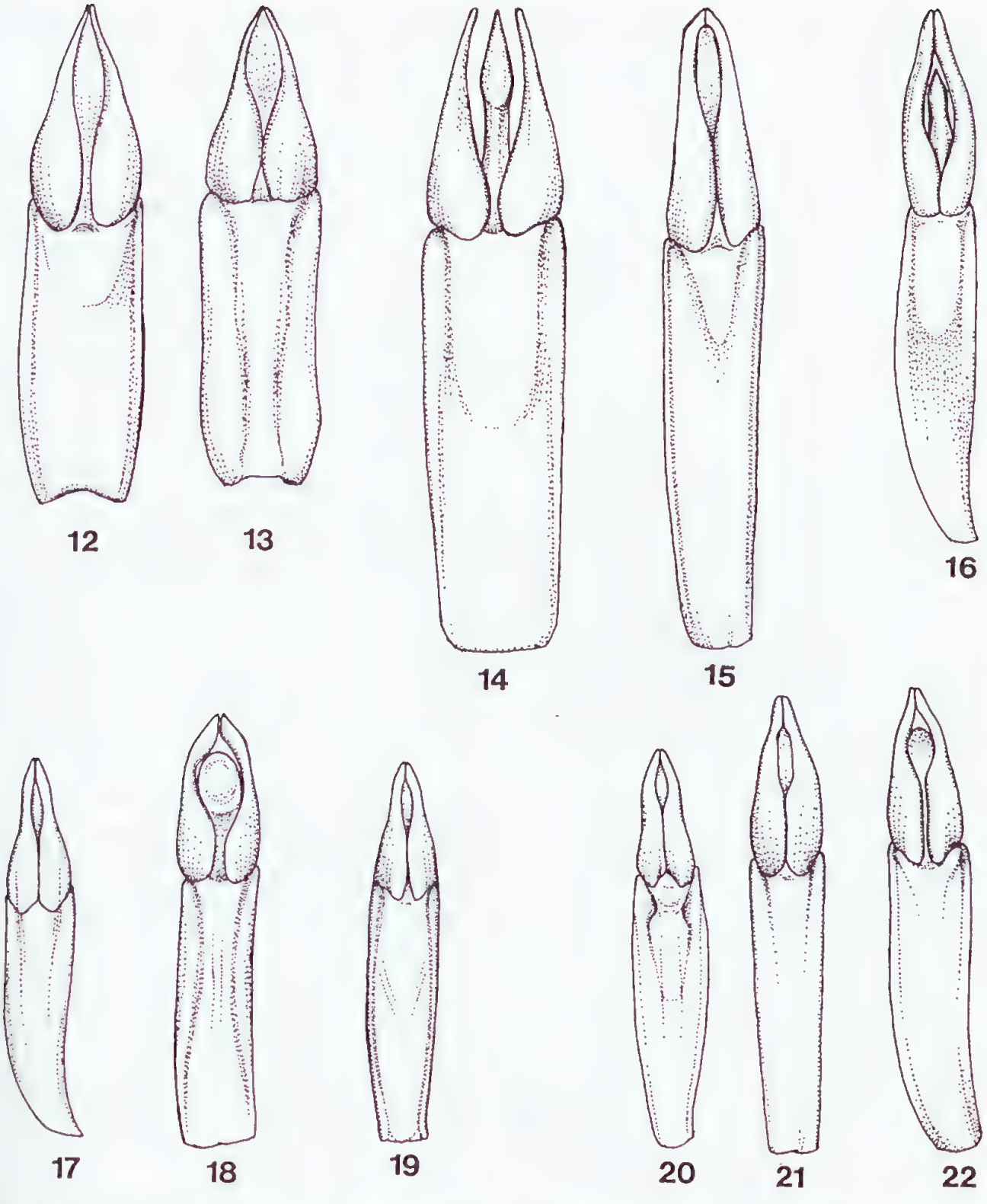
Latin. 'Dressed in black' – a reference to its black colouring.

Hydrochus burdekinensis sp. nov.

Types

Holotype: male, 'Qld. Burdekin r E of Charters Towers. 4 May 1998 C.H.S. Watts', SAMA.

Paratypes: 60, same data as holotype, SAMA.



FIGURES 12–22. **12–13**, Ventral views of two forms of aedeagus in *H. imamkhani*; **14**, *H. umbratilis*; **15**, *H. macroaquilonius*; **16**, *H. decorus*; **17**, *H. eurypleuron*; **18**, *H. aenigmatis*; **19**, *H. atratus*; **20–22**, forms of *H. interioris*.

Description (number of specimens examined, 380) Figs 1, 11, 24

Length 2.0 – 3.3mm. Broadly elongate, elytra weakly wider behind middle, constricted slightly towards apex. Head black, often with greenish iridescence; pronotum light testaceous, sometimes darker testaceous on disc or, rarely, over whole pronotum; elytra usually light testaceous to testaceous, with darker elytral spots varying from absent to moderate, spots sub equal

in size (Fig. 11), occasional specimens mainly from western Arnhem Land are silver/golden/greenish on most of the dorsal surface; ventral surface testaceous to black, legs yellow testaceous except for darker tip to tarsi. Setae lacking on dorsal surface. Head sparsely to moderately covered with weak punctures, epicranial suture weak. Pronotum varying from smooth with moderate punctures to rugose/punctate to densely covered with small granules. Elytral punctures small to moderate, area between them within striae usually less than width of interstriae, occasionally with weak to moderate granules; interstriae not or only weakly raised; plicae present. Pronotal epipleuron distinct, shiny, two to three punctures deep, occasionally fluted. Pseudoepipleuron moderate, elytral epipleuron absent behind, narrow in middle, widening only slightly in front third. Front of mesosternum in centre with two longitudinal carinae, area between them moderately excavated. Profemur moderate, basal pubescence weak, reduced to narrow band ventrally. Mesofemur spindle shaped, narrowing to half to a third greatest width, basal pubescence very weak to moderate, reduced to a narrow band ventrally. Metafemur stouter than mesofemur.

Male: Basal piece of aedeagus with sides parallel, 2.0 – 2.7 times length of apical piece. Apical piece bullet-shaped, central lobe moderately wide, pointed, nearly as long as parameres (Fig. 24).

Distribution

Northern Territory

5 km SE Mt Borradaile Station, SAMA; 33 km SW Borroloola, ANIC; 14 km NW Cape Crawford, ANIC; Cooper Creek near Mt Borradaile, SAMA; Deaf Adder Gorge Kakadu NP, NTM; Edith Falls near Katherine, CAL; Jim Jim Creek, Kakadu NP, ANIC; Jim Jim Falls, Kakadu NP, CLH, NHMW; 1 km W Gubara, Kakadu NP, SAMA; Malapanbango Creek Kakadu NP, NTM; 8 km E Mt Cahill, ANIC; 9 km SSE Mudginbarry Homestead, ANIC

Queensland

Boar Pocket Road, ANIC; Burdekin River, SAMA; Burdekin River E of Charters Towers, SAMA; Bushy Creek, Mossman – Mt Lewis Road, ANIC; Cardstone, ANIC; Charters Towers, SAMA; Hann River, NMV; Kuranda, ANIC; 73 km NW by W Laura, ANIC; 70 km N Laura, DPIM; Lake Tinaroo, ANIC; Mary Creek, ANIC, SAMA; 60 km NW Mt Isa, SAMA; 60 km W Mt Garnet, DPIM; Musgrave, DPIM; 1 km W Petford, SAMA; 1 km WSW Petford, DPIM; Strathmore Station, DPIM.

Western Australia

17 km N by E Cane River Homestead, ANIC; De Grey River, ANIC; Gascoyne River, ANIC; 12 km S Kalumburu Mission, ANIC; 4 km W King Cascade, ANIC; Millstream, ANIC; Mitchell Plateau, ANIC; Regans Ford, ANIC; Synnot Creek, ANIC; West Peawah River, ANIC, SAMA; Winjana Gorge, CAL.

Remarks

Widespread and relatively common in northern Australia, *H. burdekinensis* can be most readily recognised by its testaceous legs and, in the majority of specimens, testaceous elytra and pronotum. The darker spots on the elytra are usually not well marked and often absent.

Hydrochus burdekinensis can most easily be confused with *H. simplicicollis* which is a rarer species known only from North Queensland. Its black ventral surface and extensive area of dark testaceous on the pronotum will separate *H. simplicicollis* from most *H. burdekinensis*. *Hydrochus simplicicollis* also has stouter mesofemora, which, unlike *H. burdekinensis*, are similar in shape to the metafemora although a bit smaller overall. The apical pieces of the male aedeagi differ considerably in comparative length between the two species (Figs 24 – 27). *Hydrochus lateviridis* is generally a smaller species with greenish tinges and much more strongly developed dark markings on the elytra (Figs 9, 10). Some specimens of *H. obsoletus* from New South Wales are identical in colour to some *H. burdekinensis* but differ in having stouter legs and a more elongate apical piece of the aedeagus. In the Northern Territory specimens are often a rather uniform greenish/golden on the dorsal surface and can be confused with smaller specimens of *H. macroaquilonius*. They can be separated from this species by their yellow legs, stronger elytral epipleura and better developed pronotal epipleura. The aedeagus of *H. macroaquilonius* can not be separated from the more elongate forms of the aedeagus of *H. burdekinensis* which can be found in the same region.

Biology

A common species in bare sand at the edge of moderate to large rivers. Taken at light.

Etymology

A reference to the river where the species is particularly common.

Hydrochus cucullatus sp. nov.

Types

Holotype: male, '2 km N Mt Molloy Qld. 5.2.97 C. Watts', SAMA.

Paratypes: 3, same data as holotype, SAMA; 1, 'Peach Ck. N. Qld. 24/7/82 C. Watts', SAMA; 3, '(19°10S 145°47E) Running River, Q 24 km W, of Paluma, 13.1.70, pools in sandy river bed Britton & Misko', ANIC; 3, 'Kambah Pool ACT 26/11/98 C. Watts' SAMA.

Description (number of specimens examined, 11) Fig. 23

Length 2.3 – 3.5mm. Broadly elongate, widest just behind middle of elytra. Head black with greenish iridescence; pronotum dark testaceous with lighter front edge; elytra steely grey to dark testaceous with small darker spots, spots near suture approximately same size, spot over plica tending to be stronger; ventral surface testaceous to black, legs testaceous, apex of tarsi darker. Head sparsely granulate/punctate, epicranial suture weak. Pronotum with quite dense, strong deep punctures, smaller and more rugose at sides, surface uneven, front edge thickened, raised, forming a weak hood over neck of head. Elytra with relatively strong punctures, separated within striae by same width or less than interstriae, interstriae two and four weakly to moderately raised, more strongly near base and again near middle, interstria eight moderately raised in front of plica and incorporating plica. Pronotal epipleuron moderately delineated, about two to three punctures deep, often fluted. Front of mesosternum in middle with two narrow longitudinal carinae, area between them quite deep, pseudoepipleuron weak to moderate, elytral epipleuron absent behind, very narrow in middle widening to about same size as pseudoepipleuron in front third. Profemur elongate, basal pubescence weak, reduced to narrow band ventrally. Mesofemur spindle shaped, narrowing toward base to between one third and one half its greatest width; basal pubescence moderate, reaching a little beyond end of trochanter. Metafemur somewhat thicker and less spindle shaped than mesofemur.

Male: Basal piece of aedeagus broad, narrowing a bit towards base, 1.6 – 1.7 times length of apical piece. Parameres bulbous at base, narrow and paddle-shaped in apical half. Central lobe broad, much shorter than parameres, leaving gap in front of it between the parameres (Fig. 23).

Distribution

Australian Capital Territory

Kambah Pool, SAMA.

Queensland

2 km N Mt Molloy, SAMA; 24 km W Paluma, ANIC; Peach Creek, SAMA.

Remarks

A seemingly rare species relatively close to *H. burdekinensis*. It differs from this species by the more uneven, almost foveate, pronotum and the greater tendency for the elytral interstriae to be raised. The raised, thickened front edge of the pronotum in *H. cucullatus* is distinctive, as is the male genitalia with wide basal piece, short central lobe and paddle-shaped tips to the parameres. The aedeagus most closely resemble that of *H. interioris* but in that species the parameres are shorter and the central lobe comparatively longer. Otherwise *H. interioris* is uniformly iridescent on the dorsal surface, has dark legs, lacks forms with testaceous ventral surface, often has the pronotum with foveae and lacks the raised front margin of the pronotum.

The testaceous ventral surface, raised interstriae, raised front margin of pronotum and aedeagus will separate it from the other species with wholly testaceous legs.

Biology

The few known specimens have been taken at the edge of sandy rivers or in sandy areas at the edge of ponds.

Etymology

Latin. 'Hooded' – in reference to the raised hood-like front edge of the prothorax.

Hydrochus decorus sp. nov.

Types

Holotype: male, 'Qld Greenvale 70 km SW at light 14–24 Mar. 1995 A. J. Watts', SAMA.

Paratypes: 28, same data as holotype, SAMA; 11, same data as holotype except 12–21 Apr., SAMA.

Description (number of specimens examined, 72) Fig. 16

Length 2.3 – 3.4mm. Relatively broad, elytra widening behind middle, rapidly narrowing to apex. Dorsal surface shiny, usually with strong greenish golden reflections; elytra typically with three to four darker spots near suture, one on shoulder and one on plica, anterior sutural spot usually largest. Ventral surface brown to dark brown, legs light to moderately testaceous, parts of tarsi, knees and parts of femora darker. Setae absent from dorsal surface, or virtually so. Head strongly granulate/punctate, epicranial suture weakly to moderately developed. Pronotum dorsally granulate/punctate, foveae weakly developed. Elytra with moderate, rather evenly sized punctures, interstriae granulate to varying degrees, alternate interstriae weakly to moderately developed, plica incorporated into interstria eight. Pronotal epipleuron moderately well marked, one to two puncture widths wide. Elytral epipleuron broad to very broad, narrowing rapidly in apical fifth, lacking pseudoepipleuron. Front of mesosternum in middle with two weakly raised longitudinal carinae, area between them with vague raised portions in a rough cross shape. Profemur stout, rapidly narrowing to base, basal pubescence weak, virtually lacking ventrally. Mesofemur extremely spindle-shaped with narrow basal portion about one third of greatest width, basal pubescence weak, in very narrow band along junction with trochanter ventrally. Metafemur elongate, narrowing basally to about half greatest width.

Male: Basal piece of aedeagus long, parallel sided or narrowing at base, sometimes weakly twisted, 1.5 – 1.7 times length of apical piece. Apical piece narrow at base, widening to middle then narrowing to sharp point. Central lobe moderately broad, a little shorter than parameres (Fig.16).

Distribution

Northern Territory

5 km SE Mt Borradaile Station, SAMA; Morianty Creek, SAMA; Palm Creek, NTM; Roderick Creek, Gregory N P, NTM.

Queensland

Burdekin River near Charters Towers, SAMA; Bushland Beach, 20 km N Townsville, SAMA; Dalrymple, 30 km N Charters Towers, NHMW; Einasleigh River, DPIM; 70 km S Greenvale, SAMA; Laura, SAMA; Mitchell River, DPIM; Mt Mulligan, DPIM; 16°28S 144°46E, ANIC.

Western Australia

Fitzroy River, ANIC; 12 km S Kalumburu, ANIC; 4 km W King Cascade, ANIC; 6.5 km N Mt Bell, WAM; 3 ml E Pago Mission, FIELD; Synnot Creek, ANIC.

Remarks

Hydrochus decorus is close to *H. eurypleuron* but the majority of specimens of *H. decorus* can be separated from *H. eurypleuron* by their broader shape, bright green/golden colour and darker spots on elytra. The aedeagus of *H. decorus* is unusual in having the base of the parameres narrower than the middle, otherwise there is little difference between the two species. In occasional specimens the colour is generally duller and the elytral spots indistinct. These can be difficult to distinguish from *H. eurypleuron* except by the aedeagi. The occasional specimen of *H. interioris* can be mistaken for *H. decorus* (or *H. eurypleuron*) but these have a more extensive development of the pseudoepipleura, are generally narrower and lack or virtually lack granulation on the pronotum and elytra.

Biology

I have collected this species from sandy areas at the side of moderate to large rivers in similar habitat to *H. burdekinensis* and *H. lateviridis*. Taken at light.

Etymology

Latin. 'splendid' – in reference to the bright green jewel-like qualities of some specimens.

Hydrochus eurypleuron sp. nov.

Types

Holotype: male, 'Qld. Greenvale 70 km SW at light 12–21 Apr 1995 A. J. Watts', SAMA.

Paratypes: 11, same data as holotype, SAMA; 12, same data as holotype except 14–24 Mar, SAMA.

Description (number of specimens examined, 50) Figs 8,17

Length 1.8 – 2.7mm. Moderately elongate, elytra widened behind middle, rapidly narrowing to apex, weakly to quite strongly serrate laterally. Dorsal surface dark brown to black; ventral surface dark brown to black; legs light to moderately testaceous, parts of tarsi and femora often darker. Head strongly granulate, pronotum densely and strongly granulate/punctate, foveae

indistinct, shallow. Epicranial suture weakly to moderately impressed. Elytral punctures moderate, even sized over most of elytra, interstriae weakly to strongly granulate, alternate interstriae moderately raised, particularly towards apex and interstria eight, plica incorporated into interstria eight. Front of head and apex of elytra with weak-moderate setae. Pronotal epipleuron moderate, very poorly differentiated from top of pronotum. Pseudoepipleuron absent or weakly developed at apex only, elytral epipleuron wide, narrowing rapidly towards extreme apex. Front of mesosternum in the middle relatively smooth but with two short longitudinal carinae just traceable. Profemur stout but rapidly narrowing basally to less than half its greatest width, basal pubescence weak, reduced to a narrow band ventrally. Mesofemur elongate, becoming very narrow basally, basal pubescence weak stretching in a narrow band along junction with trochanter ventrally. Metafemur elongate, narrowing towards base to about half greatest width.

Male: Basal piece of aedeagus weakly twisted, narrowing near base, 1.5 – 1.7 times length of apical piece. Apical piece narrow, bullet shaped or weakly constricted towards apex. Central lobe narrow, nearly as long as parameres (Fig. 17).

Distribution

Northern Territory

Barramundi Gorge, Kakadu NP, CLH, NHMW; 8 km ESE Cape Crawford, ANIC; Edith Falls near Katherine, CAL; Katherine Gorge, DPIM; Kongarra, ANIC; 8 km ENE Victoria River Downs, ANIC.

Queensland

Boggy Creek near Cooktown, ANIC; Burdekin River, SAMA; 20 km NW Charters Towers, NHMW; Einasleigh River, DPIM; 70 km S Greenvale, SAMA; Iron Range, ANIC; Laura, DPIM; 21 km E Mareeba, DPIM; 23 km N Mareeba, DPIM; Palm Creek, DPIM; 5 km SE Mt Borradaile Station, SAMA; Reid River near Mingela, SAMA; 15 km NNW South Johnstone, DPIM; Tolga, DPIM.

Western Australia

Carson Escarpment, ANIC; Fitzroy River, ANIC; 14 km S by W Kalumburu Mission, ANIC; King Edward River, ANIC; Millstream, ANIC; 3 km NW Millstream, ANIC; 1 km NNE Millstream, ANIC; Mining camp Mitchell Plateau, ANIC; 4 km S by W Mining camp Mitchell Plateau, ANIC; Synnot Creek, ANIC; Wittenoom Gorge, CAL.

Remarks

Most readily separated from the closely related *H. decorus* by its duller dorsal colour and lack of elytral spots. In an occasional specimen, mostly from the Kimberley, vague dark spots can be seen in certain lights. In general it is a narrow species and does not reach the broad form with strongly serrated elytral edges quite frequent in *H. decorus*. Some specimens of *H. interioris* could be confused with this species due to their comparatively well developed elytral epipleura and weak pseudoepipleura. Apart from the presence of the pseudoepipleura, these lack, or virtually lack, granules on the pronotum and elytra and usually have quite well marked spots on the elytra.

Biology

The little habitat information available suggests that this species lives at the edge of small to moderate-sized sandy rivers. Taken at light.

Etymology

Greek. 'wide ribbed'– in reference to the very broad epipleura in this species.

Hydrochus interioris Blackburn

Hydrochus interioris Blackburn, 1896

Types

Lectotype: 'Ellery Cr' 'Cent-Aust Coll Horn Pres 7–97' 'Hydrochus interioris Blackb.', with more recent red labels 'Type' 'Syntype T-13206 Hydrochus interioris Blackburn, 1896', NMV. Herein designated.

Paralectotypes: 1 'Paisley Bluff Cent. Aust. Horn Exp.' 'Hydrochus interioris Blk del by Blkb' 'F.E. Wilson Collection' with more recent blue labels '2296 Cotype' 'Paratype T-2296 Hydrochus interioris Blackb', NMV; 1, '5489 Paisly, Bl' 'Hydrochus Horni Bl Co-t' 'Id by A.M. Lea Griffith Collection' 'Really is interioris Bl made a mistake in labelling co-types', SAMA; 1, '5489 Paisly Bl' 'Hydrochus Horni Blackb Co-type', SAMA; 1, '5489 Paisly Bl' 'Horni, Blackb' 'this is interioris, Bl', SAMA. Herein designated. I agree with Lea's comments on the SAMA specimens. See also Lea (1926). In NMV there are additional specimens obviously collected and labelled at the same time as the ones later labelled

as cotypes. I am unaware why some have been labelled as cotypes and others not. The SAMA cotypes where labelled as such by Blackburn albeit incorrectly.

Description (number of specimens examined, 261) Figs 5, 20–22

Length 2.1 – 3.3mm. Narrowly to moderately elongate, elytra widened slightly to considerably behind middle, narrowing quite rapidly to apex. Head black/silvery/golden; pronotum black often with bright silver reflections; elytra dark brown-black, often with bright silver or occasionally golden reflections, black spots visible to varying degrees dependent on background colour; ventral surface dark brown; legs testaceous, parts of tarsi and femora darker. Head granulate/punctate, epicranial suture weakly to moderately impressed. Pronotum rugose/punctate to granulate. Elytra with moderate punctures, distance between them within striae same as distance between striae, granules absent to strong, apical punctures often well marked; elytral interstriae not or only slightly raised. Setae on head and apex of elytra weakly to moderately developed. Pronotal epipleuron moderately developed, two to three punctures deep, fluted. Pseudoepipleuron moderately to well developed, elytral epipleuron absent behind, increasing in front to about equal width of pseudoepipleuron. Front of mesosternum in middle with two longitudinal carinae, area between them deeper in front than behind. Profemur quite stout, narrowing to about half its greatest width basally, basal pubescence weak reduced to a narrow band ventrally. Mesofemur elongate, spindle-shaped, reduced to about half its greatest width in basal third, basal pubescence weak, reduced to narrow band ventrally, usually less than a quarter of its basal width. Metafemur elongate, bowed on front edge, reduced to almost half its greatest width near base.

Male: Basal piece of aedeagus straight sided, 1.5 – 2.6 times apical piece. Apical piece varying from elongate triangular to bullet-shaped. Parameres narrowly to moderately broad apically. Central lobe rather narrow to moderately wide, shorter than parameres, tip rounded, occasionally with a hint of a twist at tip (Figs 20–22).

Distribution

Northern Territory

32 km W Alice Springs, ANIC; Barramundi Creek, Kakadu NP, SAMA; Barramundi Gorge, Kakadu NP, NHMW, CLH; 22 km WSW Borroloola, ANIC; 80 km SW Borroloola, ANIC; 8 km ESE Cape Crawford, ANIC; 14 km NW Cape Crawford, ANIC; Cooper Creek near Mt Borradaile, SAMA; Ellery Gorge, ANIC, SAMA, NMV; 11 km E Jabiru, SAMA; 20 km SSW Jabiru, SAMA; Jim Jim Highway, Kakadu NP, NHWM, CLH; Jim Jim Falls, Kakadu NP, NHWM, 1 km W Gubara, Kakadu NP, SAMA; Gungurul Lookout, Kakadu, NHWM; Howard Springs, ANIC, SAMA; Kongarra, ANIC, NTM; Litchfield NP, ANIC; 1 km NNW Mudginbarry Homestead ANIC; 19 km E by S Mt Borradaile, ANIC, NTM; 6 km SE Mt Borradaile, SAMA; 19 km WSW Mt Cahill, ANIC; 8 km E Mt Cahill, ANIC; Nabarlek Dam, ANIC; 46 km WSW Mt Cahill, ANIC; 15 km E Mt Cahill, NTM; Nawurlandja, Kakadu NP, SAMA; 18 km E by N Oenpelli, ANIC; Orminston Gorge, SAMA; Paisley Bluff, NMV; Pine Creek, NTM; Roderick Creek, NTM; Simpsons Gap, SAMA; UDP Falls, Kakadu NP, NTM; Vaughan Springs, SAMA.

Queensland

20 km S Bloomfield, SAMA; Burdekin River, SAMA; Burdekin River E of Charters Towers, SAMA; 30 ml N Cooktown, UQIC; Coen, SAMA; 24 ml SE Einasleigh, CAL; 70 km SW Greenvale, SAMA; Iron Range, UQIC; McLeod River near Cooktown, SAMA; McIlwraith Ranges Weather Station, SAMA

Western Australia

Drysdale River, ANIC; 12 km S Kalumburu Mission, ANIC; 14 km S by E Kalumburu Mission, ANIC; 4 km W King Cascade, ANIC; King Edward Range, ANIC; Mining Camp Mitchell Plateau, ANIC; 4 km WSW Mining Camp Mitchell Plateau, ANIC.

Remarks

As I have interpreted it, *H. interioris* is a common, widespread and variable species across northern and central Australia. It does not appear to be present east of the Dividing Range. In the Kimberley and coastal Northern Territory most specimens are narrow, weakly granulate, often with a silvery or less frequently a golden sheen and their aedeagi are relatively broad. At the eastern edge of their range on Cape York, Queensland, they are strongly granulate and often broad, with narrower more elongate aedeagi, and darker although when wet the typical dark spots and silvery patches are usually clear. The type population in central Australia tends to be intermediate.

Hydrochus interioris can most easily be separated from related species by its dark legs, uneven surface to the pronotum, narrow mesofemur but only moderately narrowed metafemur, weak basal pubescence on mesofemur, the frequent presence of moderate apical punctures, often silvery elytra with simple but often masked pattern of dark spots and, particularly in Queensland specimens, very strong dorsal granules. The aedeagus is unusual in having the basal half of the parameres often swollen ventrally rather than the more usual dorsally.

It can be confused with *H. macroaquilonius* (see under that species) and *H. eurypleuron* which is superficially similar but has much broader elytral epipleura, and *H. aenigmatis*, a more southerly species, with broader mesofemora with stronger basal pubescence, elytra and pronotum not granulate and with a very broad short central lobe to the aedeagus. Small specimens are difficult to distinguish from *H. atratus* (see under that species).

Biology

This common and widespread species is found in bare sandy areas beside creeks and rivers or the pools left in drying river beds. Taken at light.

Hydrochus lateviridis Blackburn

Hydrochus lateviridis Blackburn, 1896

Type

Holotype: male 'Ellery ck' 'Cent. Aust. Coll. Horn Exp. Pres. 8.98' 'Hydrochus lateviridis Blackb' with more recent red labels 'Type' 'Holotype T-13211 Hydrochus lateviridis Blackburn, 1896', NMV.

Description (number of specimens examined, 290) Figs 9, 10, 25–27

Length 1.6 – 2.5mm. Broadly elongate, pronotum narrowed quite strongly behind, elytra quite strongly widened behind middle, rapidly narrowing to tip. Head black to golden, iridescent; pronotum dark brown to golden iridescent, front and rear margins occasionally narrowly testaceous; elytra dark brown, or steely grey, or silvery/golden, elytral dark spots often well marked, often extensive (Figs 9,10); ventral surface dark brown to black, legs yellow or light testaceous, usually lacking darker areas on knees or femora. Head granulate/punctate, epicranial suture weakly impressed. Pronotum rather evenly and smoothly covered in small to moderately sized punctures, moderately rugose. Elytra with small to medium sized punctures, distance between punctures often less than the width of interstriae, interstriae not or only very weakly raised; plica distinct; apical punctures small, may be weakly granulate. Setae on head and elytra virtually absent. Pronotal epipleuron well marked, two to three puncture widths deep, smooth with some large punctures. Elytral pseudoepipleura weak to moderate, epipleura absent behind, widening to about same width or a bit more than pseudoepipleura in front third. Front of mesosternum in centre with two longitudinal carinae, area between them shallow behind. Profemur elongate, narrowing toward base; basally pubescence weak, reduced to narrow band ventrally. Mesofemur strongly spindle-shaped, reducing to half or less its maximum width basally, basal pubescence very weak, reduced to narrow band ventrally. Metafemur spindle-shaped, narrowing to about half its greatest width basally.

Male: Basal piece of aedeagus straight sided to moderately twisted, 1.5 – 2.6 times length of apical piece. Apical piece bullet-shaped to elongate, occasionally twisted, base narrower than basal piece. Central lobe varying from relatively thin and parallel sided to quite strongly expanded apically, in both cases with a very thin apical piece which almost reaches tip, often bulging above parameres apically. The thin apical piece of the central lobe may be displaced laterally in strongly twisted or elongate forms (Figs 25–27).

Distribution

Northern Territory

Adelaide River, ANIC; Barramundi Creek, Kakadu NP, SAMA; Deaf Adder Gorge, Kakadu NP, NTM; 14 km NW Cape Crawford, ANIC; Cooper Creek near Mt Borradaile, SAMA; Edith Falls near Katherine, CAL; Ellery Gorge, ANIC; Gubara, Kakadu NP, NHMW, CLH; 20 km SSW Jabiru, SAMA; Kongarra, NTM; 19 km E by S Mt Borradaile, NTM, ANIC; 6 km SE Mt Borradaile, SAMA; 6 km E Mt Cahill, ANIC; 8 km E Mt Cahill, ANIC; 19 km WSW Mt Cahill, ANIC; 5 km SE Mt Borradaile Station, SAMA; 2 km N Mudginbarry Homestead, ANIC; 9 km SSE Mudginbarry Homestead, ANIC; 11 km S by W Nimbuwah Rock, ANIC, NTM; Nawurlandja, Kakadu NP, SAMA; 6 km SW by S Oenpelli,

ANIC; Roderick Creek, NTM; Simpsons Gap, SAMA; South Johnstone River, Kakadu NP, SAMA; UDP Falls, Kakadu NP, NTM; Woolwonga Fauna Reserve, ANIC; 16.07S 130.25E, NTM.

Queensland

Borumba Dam, NHMW; Burdekin River, SAMA; Burdekin River E of Charters Towers, SAMA; 35 ml SE Burketown, UQIC; Cape Tribulation, DPIM; Dalrymple, NHMW; Funnel Creek, ANIC; 70 km SW Greenvale, SAMA; Hann River, NMV; Laura, DPIM; 73 km NW Laura, ANIC; 66 km NW Mt Isa, ANIC; 3 km ENE Mt Tozer, ANIC; Normanton, ANIC; 11 km NSW Petford, DPIM; 15 km WNW South Johnstone, DPIM; Windsor Table Land, DPIM.

Western Australia

Abydos, FIELD; Cadjeput Rockhole, WAM; 17 km N by E Cane River Homestead, ANIC; Drysdale River, ANIC; 12 km S Kalumburu Mission, ANIC; 3 km NW by W Millstream, ANIC; 4 km S by W Mining Camp Mitchell Plateau, (14°52S 125°50E), ANIC; 5.5 km NW Mt Bell, WAM; West Peawah River, ANIC; Winjana Gorge, CAL.; 13 km ESE Wittenoom, ANIC; Synnot Creek, ANIC.

Remarks

Typical *H. lateviridis* have a large triangular dark patch just before the middle of the elytra which separates them from all other Australian *Hydrochus* (Figs 9,10). However this patch can be obscured in dark specimens and, particularly in Arnhem Land, can be reduced to a small area no larger than other patches on the elytra which then resembles the pattern in other species such as *H. burdekinensis*. Dark specimens of *H. lateviridis* can be confused with *H. atratus*, particularly the occasional specimen of *H. atratus* with yellow legs, but can be separated by their wider elytral epipleura, more spindle-shaped mesofemora, and better defined pronotal epipleura. All these characters are subjective and can only really be appreciated when directly comparing specimens. The genitalia can be very similar but in *H. atratus* (Fig.19) the apical piece is more triangular and with a narrower central lobe than in *H. lateviridis*. In some *H. atratus* (if the specimens from Kunmunya are included in that species) (Figs 25–27) the apical piece is very like the short narrow form of *H. lateviridis* (Fig. 26) but is more waisted and the central lobe not bulbous as in typical *H. lateviridis*.

Darker specimens of *H. burdekinensis*, and *H. lateviridis* with poorly developed colour patterns, resemble each other. In most cases the more spindle-shaped mesofemora of *H. lateviridis* will separate them. Their aedeagi are relatively similar and the large degree of variation makes it difficult to reliably separate them on this character alone.

There are four rather distinctive forms of the aedeagus within the species as I interpret it.

The first form has a squat, bullet-shaped apical piece with a broad, bulbous central lobe with a weak, hard to see, apical spine (Fig. 25). It appears to be a more inland form and is the only one present in the type locality in Central Australia.

The second form has a short, thin apical piece with a narrow almost parallel sided central lobe (Fig. 26). It is more coastal in distribution.

The third form is similar to the second but has the apical piece strongly skewed, and the thin portion at the tip of the central lobe can appear twisted out of position. The few specimens known are from the Hann River/Iron Range area of Cape York.

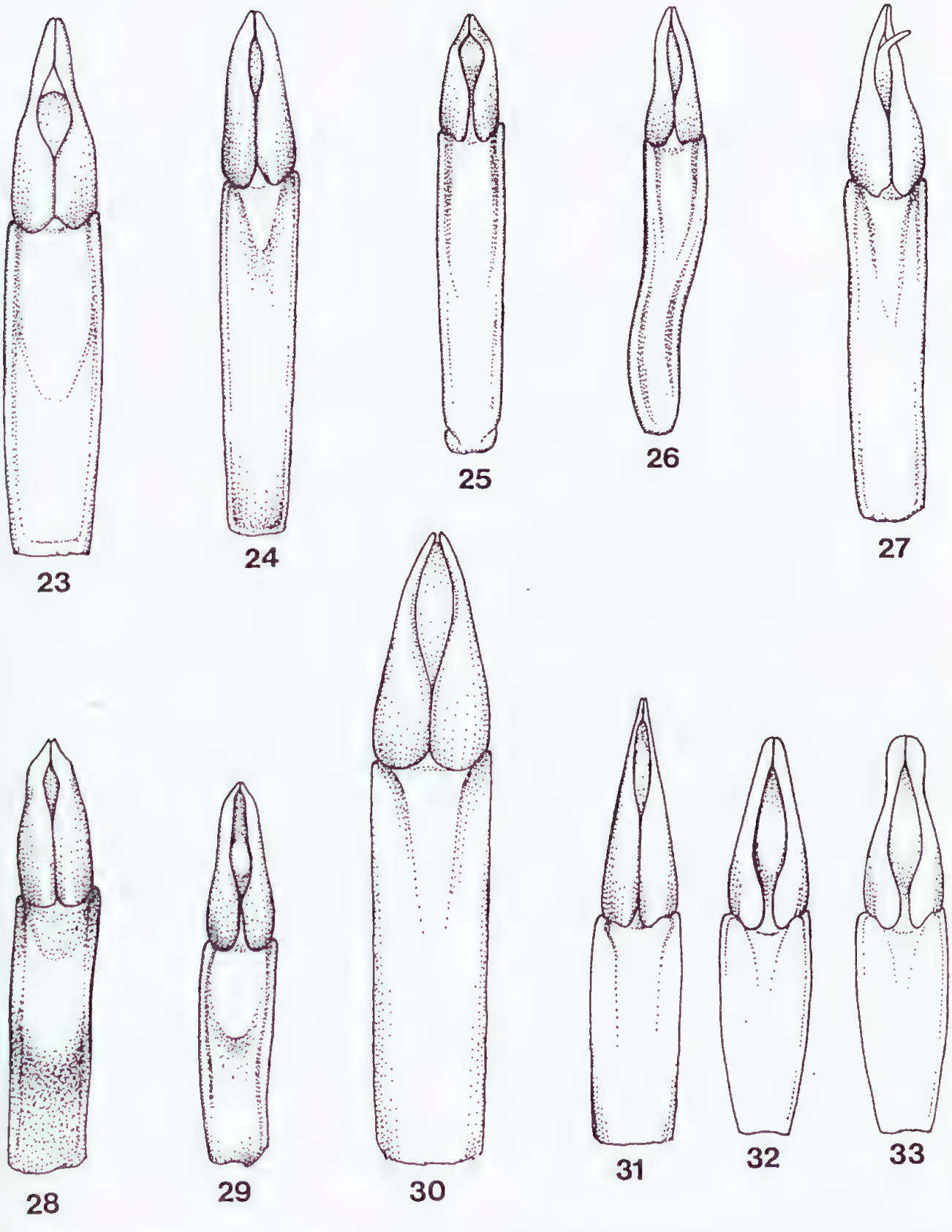
The fourth form has a longer more elongate apical piece with a correspondingly long thin central lobe, the terminal piece of which is bent at right angles in the four known specimens, presumably a post-mortem effect (Fig. 27). The specimens are from Cooktown, Hann River, Wenlock River and Archer River all on Cape York.

The first two forms are relatively common and widespread, occurring together in the same population at several locations (e.g. Greenvale and Kakadu). Although most specimens are clearly one or the other form enough intermediates exist for me to hesitate to consider them separate species.

Forms three and four are known from only a few specimens from a relatively restricted area of Cape York and are the only representatives of the species in the region so far collected. A few specimens from further south show a tendency to have a skewed apical piece to their aedeagi. Many more examples of *H. lateviridis* from Cape York will need to be examined before a better interpretation of these forms can be made.

Biology

Found in sand and gravel at the edges of rivers or in sandy pools in the beds of drying rivers. Taken at light.



FIGURES 23–33. **23**, *H. cucullatus;* **24**, *H. burdekinensis;* **25–27**, forms of *H. lateviridis;* **28**, *H. simplicicollis;* **29**, *H. obsoletus;* **30**, *H. numerosepunctatus;* **31–33**, forms of *H. obscuroaeneus.*

Hydrochus macroaquilonius sp.nov.

Types

Holotype: male, 'NT Magela ck Kakadu NP 19.3.98 C.H.S. Watts', SAMA.

Paratypes: 5, same data as holotype, SAMA; 2, '12°57S 132°33E Jim Jim Creek, N.T. 19 km WSW of Mt Cahill 24.x.72, E.B. Britton', ANIC; 2, '12°40S 132°54E Magela Creek, N.T. 9 km SSE of Mudginbarry HS, 6.xi, 72, at light, E. Britton', ANIC.

Description (number of specimens examined, 47) Fig. 15

Length 3.2 – 4.1mm. Elongate, elytra widest slightly behind middle, narrowing quite rapidly to apex which is moderately truncate. Head dark brown-black with metallic sheen; pronotum dark brown/steely grey; elytra dark brown/steely grey/golden with dark spots which are masked in darker forms; ventral surface dark brown-black, legs testaceous, knees and base of femora often darker. Head quite densely but smoothly granulate/punctate, epicranial suture weak. Pronotum rugose/punctate, punctures relatively small and dense, foveae weak. Elytral punctures moderate, separated within striae by about width of interstriae, interstriae four and eight often weakly raised, plica present. Head and elytra virtually without setae. Pronotal epipleuron ill defined, one to two puncture widths wide, may be weakly fluted. Elytral pseudoepipleuron moderate, epipleuron absent apically, increasing towards middle and front where it reaches about same width as pseudoepipleuron. Front of mesosternum in middle with two longitudinal carinae, area between them often shallow. Profemur elongate, basal pubescence weak, reduced to narrow band ventrally. Mesofemur elongate, spindle shaped, towards base less than half its greatest width, basal pubescence moderate, reaching to about quarter width of femur beyond trochanter on rear edge. Metafemur elongate, weakly bowed on front edge.

Male: Basal piece of aedeagus parallel sided, 2.0 – 2.1 times length of apical portion. Apical piece elongate, narrow. Central lobe narrow, almost as long as parameres (Fig. 15).

Distribution

Northern Territory

Barramundi Creek, Kakadu NP, CLH, NHMW; Gungural Lookout, Kakadu NP, NHMW; 20 km SSW Jabiru, SAMA; Jim Jim Creek, Kakadu NP, ANIC; Magela Creek, Kakadu NP, SAMA; 30 km WSW Mt Cahill, ANIC; 8 km E Mt Cahill, ANIC; 9 km SSE Mudginbarry Homestead, Kakadu NP, ANIC; South Johnstone River, Old Jim Jim Road Crossing, Kakadu NP, SAMA.

Queensland

3 km W by S Black Mountain, ANIC; 20 km S Bloomfield, SAMA; Captain Billy Creek, SAMA; Coen, UQIC; Helenvale, SAMA; 7 km N of Hope Vale Mission, ANIC; Iron Range, DPIM; 73 km NW by W Laura, ANIC; Palm Creek, DPIM; Peach Creek, SAMA; McIlwraith Ranges Weather Station, SAMA; 9 km ENE Mt Tozer, ANIC; 11 km ENE Mt Tozer, ANIC; 3 km ENE Mt Tozer, ANIC; 1 km N Rounded Hill, ANIC; 5 km W by N Rounded Hill, ANIC.

Western Australia

8 km SW by W Cane River Homestead, ANIC; Gascoyne River, SAMA; 23 ml N Mundiwindi, WAM.

Remarks

One of the largest Australian *Hydrochus*, *H. macroaquilonius* is close to *H. interioris*. It differs in its larger size, lack of granules, somewhat more extensive basal pubescence on the mesofemur with the pubescence reaching beyond the hind edge of the trochanter even in the middle of the femur. In *H. interioris* it is seldom as well developed. The aedeagus resembles that seen in some of the highly granulate eastern specimens of *H. interioris* but has the central lobe a bit broader and longer than most of these. The epipleura also tend to be broader than in the majority of *H. interioris*. Most specimens have the legs with a much lesser extent of dark colour than in *H. interioris* and in a few specimens the legs are uniformly testaceous. The bright golden dorsal surface seems a rarity in this species, most specimens being a rather dull grey with the spots only vaguely visible. In general appearance it resembles *H. imamkhani* another large species with elytral spots, and sympatric with it. The structure of the front of the mesosternum will readily separate these two species.

Biology

Found among sand and gravel at the edges of rivers and small creeks. Taken at light.

Etymology

Latin. 'Large', 'northern' – a reference to its size and locality.

Hydrochus obsoletus Lea

Hydrochus obsoletus Lea, 1926

Type

Holotype: female 'obsoletus Lea TYPE Albury', SAMA

Description (number of specimens examined, 170) Fig. 29

Length 2.0 – 3.4mm. Broadly elongate, widest just behind middle of elytra. Head black or golden, weakly iridescent; pronotum testaceous to dark testaceous with green tinges, front and/or rear margins sometimes narrowly testaceous, or golden, or all black; elytra light testaceous with vague similar sized darker spots, or shiny silver grey with darker spots, or shiny golden with dark spots, or shiny black; ventral surface black, legs light testaceous with tips of tarsi, and occasionally base of femora diffusely darker. Head smooth, sparsely covered with small moderate punctures, frons area often granulate, epicranial suture weak. Pronotum smooth, rather sparsely covered with moderate punctures to rugose and closely punctured. Elytra with small to moderate punctures, separated within striae by the width or less of the adjacent interstriae, sometimes weakly granulated at sides and rear; interstriae not or only weakly raised – if so then interstria four is most prominent; plica weak to moderate. Dorsal setae absent. Pronotal epipleuron well marked, shiny, two to three puncture widths deep. Front of mesosternum in middle with two longitudinal carinae, area between them shallower behind. Pseudoepipleuron relatively broad, epipleuron absent behind, narrow in middle, widening to a bit less than width of pseudoepipleuron in front third. Profemur quite stout; basal pubescence weak, reduced to a narrow band ventrally. Mesofemur relatively stout for group 2 species, narrowing to about two thirds its greatest width basally, basal pubescence weak to moderate, reduced to narrow band about a quarter width of base of femur or less, ventrally. Metafemur a bit larger but similar in shape to mesofemur.

Male: Basal piece of aedeagus narrowing weakly toward base, 1.5 – 2.0 times length of apical piece. Apical piece narrowly bullet-shaped to triangular with suggestion of subapical constriction. Central lobe relatively narrow, weakly bulbous in its central portion, a bit shorter than parameres (Fig. 29).

Distribution

Australian Capital Territory

Black Mountain, ANIC; Canberra, SAMA; 30 km SW Canberra, SAMA; Kambah Pool, ANIC, SAMA.

New South Wales

Armadale, SAMA; Bombala, SAMA; Boonoo Boonoo River, UQIC; Cabbage Tree Creek near Nelligen, SAMA; Clarence River, NMV; Cooma, SAMA; Gilgandra, SAMA; Jenolan Caves, SAMA; 6 km N Uralla, ANIC; Valery, ANIC; Quaama, SAMA.

Queensland

Bowen, SAMA; 15 km W Gympie, NMV; Kenilworth State Forest, UQIC; 10 km W Imbil, NMV.

South Australia

Cudlee Creek, SAMA; Torrens Gorge, SAMA.

Victoria

11.5 km NNW Ballan, ANIC; Benong, CAL; 3.8 km WNW Blackwood, ANIC; Deddick River, NMV; 4.5 km SW Healesville FIELD; 4 km SW Healesville, NMV; Omeo, SAMA; 30 km N Orbost, SAMA; Stratford, SAMA.; Tambo Crossing, Jordan River, NMV.

Remarks

A southern species readily recognised from other southern species by its yellow spindly legs and coloured and spotted elytra. It resembles *H. burdekinensis* in general shape and colour but can be separated from this species by its similarly shaped meso and meta femora unlike *H. burdekinensis* which has the mesofemora more spindle-shaped. Although some *H. obsoletus* and some *H. burdekinensis* have identical dorsal colouring, apart from one specimen of *H. obsoletus* from Gilgandra, in SAMA, with a testaceous ventral surface, *H. obsoletus* always has a black, or very dark, ventral surface, whereas in most *H. burdekinensis* it is a much lighter testaceous colour. The aedeagi of both species are quite similar but in *H. obsoletus* the apical piece is comparatively longer (1.5 – 2.0 times the length of the basal piece) and the paramere tips a bit wider.

Hydrochus obsoletus closely resembles *H. simplicicollis* and can only be reliably separated by its aedeagus which has a relatively shorter apical piece compared to *H. simplicicollis* (Figs 28, 29). Future study, particularly of specimens

from coastal Queensland, may well show these two species to be conspecific.

Biology

All specimens of this species that I have collected have been taken from among gravel at the edge of relatively large streams/rivers.

Hydrochus simplicicollis Lea

Hydrochus simplicicollis Lea, 1926

= *Hydrochus verae* Makhan, 1995; syn. nov.

Types

Hydrochus simplicicollis Lea. *Lectotype*: 'simplicicollis Lea TYPE Cairns' left hand specimen of two on same card with 'TY' below, SAMA. Herein designated.

Paralectotypes: 1, same data as holotype, SAMA; 1, 'Vicinity of Jenolan Caves (J.C. Wiburd)' 'Co-type' 'Griffith Collection Id. by A.M. Lea', SAMA. Herein designated. This specimen is labelled as a co-type but not by Lea. In the original description it is mentioned by Lea as 'probably belongs to the species'. Its paralectotype status is doubtful. This specimen belongs to *H. obsoletus*.

Hydrochus verae Makhan. *Holotype*: 'Australien QL (10,11) Dalrymple 300 m, 30 km N. Charters Towers 18.1.1993 leg Wewalka' 'Hydrochus verae det. D. Makhan 1994' with red Holotype label, NHMW.

Paratypes: 7, same data as holotype with yellow paratype labels, NHMW. (The paratype series includes three species; four are conspecific with the holotype, two are *H. lateviridis* and one is *H. atratus*).

Description (number of dissected males examined, 14) Fig. 28

Length 2.0 – 2.4mm. Broadly oval, widest just behind middle of elytra. Head black, often with greenish tinges; pronotum shiny dark brown, front and rear edges often narrowly testaceous; elytra light to dark testaceous, sometimes with vague darker spots approximately equal in size, or grey/black, or black; ventral surface dark brown to black, legs light testaceous, apical portion of tarsi maybe darker. Head smooth with sparse moderate punctures, occasionally with squat granules, epicranial suture weak. Pronotum smooth to rugose, punctures moderate sized, usually rather sparse. Elytra with small, moderate sized punctures, punctures separated by less than the width of interstriae in all but a few cases; interstriae not, or only very weakly raised; plica weakly distinct. Dorsal surface without setae. Pronotal epipleuron well differentiated, shiny, about three puncture widths deep. Pseudoepipleuron of elytra moderate, epipleuron absent behind, narrow in middle, increasing to about same width as pseudoepipleuron in anterior third. Front of mesosternum in middle with two longitudinal carinae, area between them shallower behind. Profemur relatively stout; basal pubescence moderate, reduced to a band about a quarter the width of the femur at that point or less ventrally. Mesofemur moderately spindle-shaped, narrowing basally to between a third to a half its greatest width; basal pubescence weak to moderate, reduced to a narrow band about a quarter of the width of the femur or less ventrally. Metafemur a little larger but approximately the same shape as mesofemur.

Male: Basal piece of aedeagus wide, narrowing a bit towards base, 1.0 – 1.4 times length of apical piece. Apical piece elongate, narrow. Central lobe rather narrow, weakly bulbous in its central portion, as long as parameres (Fig. 28).

Distribution

Queensland

Cairns, SAMA; Dalrymple, 30 km N Charters Towers, NHMW; 70 km SW Greenvale, SAMA; 15 km WNW South Johnstone, DPIM; Windsor Tableland, DPIM.

Western Australia

3 ml E Pago Mission, FIELD.

Remarks

Like the related species, *H. obsoletus*, *H. lateviridis* and *H. burdekinensis*, *H. simplicicollis* has a range of dorsal colours but in all known specimens the pronotum is dark, apart from front and rear margins in some, and the ventral surface black or almost so and, when present, the elytral spots are roughly equal in size. Although most specimens have small elytral punctures and wide interstriae, in some specimens the punctures are larger with the interstriae narrow and equal in width to the area separating punctures within a stria. Compared to *H. burdekinensis* and *H. lateviridis*, the mesofemora are relatively stout and roughly similar in shape to the metafemora. On average the elytral epipleura seem a bit wider than in related

species but this difference is difficult to quantify. Males have longer and narrower apical pieces to their aedeagi than those of *H. burdekinensis* (Fig. 24) or *H. lateviridis* (Figs 25–27).

The species can only be separated from the southern *H. obsoletus* by the aedeagus which, in *H. obsoletus* (Fig. 29), has the apical piece comparatively shorter and broader and the central lobe is shorter and does not reach to the ends of the parameres. It is possible that the collection of specimens from the intermediate geographic areas could show them to be conspecific.

Hydrochus verae Makhan belongs to this species, although three of the seven paratypes do not. The specimens mentioned by Lea (1926) from Jenolan NSW and Bowen Qld are *H. obsoletus*.

Biology

No habitat notes are available although the general localities suggest that it lives at the edge of sandy/gravelly rivers as do related species.

Species Group 3

Group 3 species are characterised by having: two rather than three longitudinal carinae at the front of the mesosternum; stout, almost cylindrical legs, with the basal pubescence on the profemora interrupted ventrally or reduced to a very narrow band (Fig.3). Other character states that tend to define the group are: elytral interstriae, particularly the alternative ones, usually raised and the plica absorbed into interstria eight; pronotal foveae weakly to moderately developed and their edges often glabrous; pronotal epipleura moderately wide but ill-defined; head with a deep epicranial suture; dorsal setae often strong; basal pubescence on the mesofemora seldom reaches beyond the apex of the trochanter (Fig. 3).

Group 3 species are generally relatively small and chunky, although *H. numerosepunctatus* is among the largest of Australian *Hydrochus*. One species, *H. obscuroaeneus*, is extremely common across Northern Australia. The species are primarily inhabitants of smaller, often intermittent, streams where they live among stones and detritus at the edges. Two species appear to be at least partially terrestrial, having been collected from wet forest litter.

Hydrochus chitraae Makhan, 1994 and *H. chitaniei* Makhan, 1994, described from New Guinea, belong in this group.

Hydrochus gitaraiae Makhan

Hydrochus gitaraiae Makhan, 1994

Types

Holotype: male, 'New Guinea Neth Mol Maffen, 22 km E of Sarmi July 18, 1959' 'm.v. light trap Maa' 'Hydrochus gitaraiae det D. Makhan 1994', BPBM.

Paratype: same data as holotype. In Hungarian National Museum, Budapest. Not seen.

Description (number of dissected males examined, 5) Fig. 34

Length 1.8 – 2.3mm. Elongate-oval. Head shiny black; pronotum shiny dark brown to black; elytra shiny black; ventral surface dark-brown to black, legs dark testaceous, parts of tarsi, knees and much of femora darker. Head with scattered large punctures, frons weakly granulate, epicranial suture well marked. Pronotum with rather sparse large punctures, with bare areas in between, foveae obsolete. Elytra with rather even sized well marked punctures not or only slightly increasing in size towards middle within striae. Alternate interstriae weakly raised towards apex, interstriae eight weakly raised, incorporating plica. Pronotal epipleuron weakly delineated, narrow, about a puncture width wide, almost completely or partially absent in some. Pseudoepipleuron narrow posteriorly moderate anteriorly, elytral epipleuron absent behind, narrow in front. Profemur stout, basal pubescence weak, absent ventrally. Mesofemur relatively stout, weakly narrowing towards base, basal pubescence reaching to about end of trochanter on posterior margin. Metafemur moderately stout. Setae on head and basal half of elytra moderate to strong, weak to moderate on pronotum. Front of mesosternum in middle with two subparallel raised carinae, area between them moderately deep.

Male: Basal piece of aedeagus broad, weakly narrowing toward base, 1.2 – 1.5 times length of apical piece. Parameres broad at base, weakly constricted a bit before tip, tip relatively broad, diagonally truncated. Central lobe moderate, nearly as long as parameres (Fig. 34).

Distribution

Northern Territory

Muirella Park, Kakadu NP, DPIM.

Queensland

29 km S Bamaga, ANIC, SAMA; 9 km ENE Mt Tozer, ANIC.

Remarks

This seemingly rare northern species is the smallest group 3 species yet known (<2.5mm). Apart from its small size it differs from other group 3 species by its weak or, in some cases, virtually absent, pronotal epipleura, and the wide obliquely truncated tip to the parameres (Fig. 34). Among group 3 species, it shares with *H. horni* the relatively uniformly- sized elytral punctures, strongly developed setae on the head and elytra and bare shiny areas on the pronotum. Also occurs in New Guinea.

Biology

Nothing known.

Hydrochus granicollis Lea

Hydrochus granicollis Lea, 1926.

Types

Lectotype: female 'granicollis Lea TYPE Wahroonga', SAMA. Herein designated.

Paralectotypes: 2, 'Wahroonga H.J.C.1.24' 'Co-type' 'Griffith Collection id. by A.M. Lea', SAMA. Herein designated.

Description (number of specimens examined, 22) Fig. 37

Length 2.0 – 2.6mm. Relatively broad, elytra widest behind middle. Head shiny black; pronotum and elytra shiny dark brown to black; ventral surface dark brown, legs testaceous. Head rather smoothly granulate/punctate, epicranial suture well marked. Pronotum strongly granulate/ punctate, foveae weak not bounded by raised carinae. Elytra with moderate sized well impressed punctures, those in any one stria of similar size apart from extreme base and apex, adjacent punctures in different striae same size; alternate interstriae moderate to quite strongly raised, some lateral interstriae may be granulate; plica absorbed into interstria eight; apical punctures usually strong, apex rounded. Pronotal epipleuron moderate, about two puncture widths wide. Pseudoepipleuron wide, elytral epipleuron absent behind, narrow in front. Setae weakly developed on head and at base of elytra. Front of mesosternum in middle with two subparallel raised carinae, area between them moderately deep. Profemur stout, basal pubescence weak, absent or very narrow ventrally. Mesofemur relatively stout weakly narrowed towards base, basal pubescence moderately developed, reaching a little past end of trochanter on hind margin. Profemur moderately bowed on front edge.

Male: Basal piece of aedeagus parallel sided, 1.3 – 1.4 times length of apical piece. Parameres weakly bulbous in basal half, twisted open in front half to cradle central lobe, narrowing towards tip. Central lobe moderately wide, narrowing in front (Fig. 37).

Distribution

Australian Capital Territory

Black Mountain, ANIC; Cotter River, ANIC; Kambah Pool, ANIC.

New South Wales

Cabbage Tree Creek, ANIC; Hawksbury River, SAMA; Kiola Forest Park, 15 ml N Batemans Bay, ANIC.

Remarks

A southern species known only from a limited area of the South-east, *H. granicollis* resembles *H. horni* in general appearance and in its relatively even-sized elytral punctures. In general it is a chunkier species with more strongly developed dorsal sculpture but much more poorly developed setae. The apex of the elytra is rounded rather than pinched as is often the case in *H. horni* and the apical punctures are usually very large in contrast to the small to moderately sized ones in *H. horni*.

Biology

Found among stones and leaves at the edges of running water. The specimens from Kiola are labelled as coming from wet sclerophyll litter.

Hydrochus horni Blackburn

Hydrochus horni Blackburn, 1896

= *H. scabricollis* Lea, 1926; syn. nov.

Types

Hydrochus horni Blackburn. *Lectotype*: 'Type' 'T 5488 Paisl. Bl.' 'Australia Blackburn Coll BM. 1910–236' ' Hydrochus interioris Blackb.' 'Hydrochus horni Blackb. Type fide Lea TRSSA 1926– 147 Balfour Browne det', BMNH. Herein designated.

Paralectotypes: 1, 'Cent-Aust Coll Horn Exp Pres 7.97' 'Hydrochus Horni, Blackb.' with more recent red labels' 'Type' 'Syntype T-13197 Hydrochus horni Blackburn 1896', NMV. This

specimen cannot be considered the holotype since the BMNH specimen was clearly marked 'T' by Blackburn; 1, 'Paisley Bluff Cent Aust Horn. Exp' 'Hydrochus horni Blk. del. by Blkb.' 'F.E.Wilson Collection' with more recent blue labels '2295 Cotype' 'Paratype T2295 Hydrochus horni Black.', NMV; 1, '5488 Paisley B.' 'Hydrochus interioris, Blackb. Co-type', SAMA; 2, '5488 Paisl Bluff' 'interioris Blackb.' 'this is horni Bl', SAMA. Herein designated. I agree with Lea (1926) that the BMNH and SAMA specimens are *H. horni* and were mislabelled by Blackburn.

Hydrochus scabricollis Lea. *Lectotype*: 'Scabricollis Lea TYPE Parachilna', SAMA. The left hand specimen above `TY` of four specimens on one card herein designated.

Paralectotypes: 3, same data as holotype, SAMA; 1, 'S. Australia' 'A.H. Elston Collection' '2625 Hydrochus scabricollis Lea Co-type S. Australia' 'Paratype', AM; 5, 'Co-Type' 'Parachilna Hale Flinders Range' 'Griffith Collection id by A.M. Lea', SAMA; 1, 'Co-Type' 'Lucindale S. Australia', SAMA.; 2, 'Lucindale S Australia' 'Hydrochus scabricollis' 'Co-type 2795' 'Lea, Co-type', QM. Herein designated.

In NMV there are additional specimens obviously collected and labelled at the same time as the specimens later labelled as co-types. I am unaware of why some have been labelled as co-types and others not. The SAMA paralectotypes were labelled co-types by Blackburn, albeit incorrectly.

Description (number of specimens examined, 193) Figs 35, 36

Length 2.0 – 3.4mm. Elongate, elytra a little wider behind middle. Head shiny black; pronotum and elytra shiny dark brown to black; ventral surface dark brown, legs dark testaceous, parts of tarsi, knees and much of femora darker. Head granulate/punctate. Pronotum granulate/punctate varying from quite strongly and evenly rugose to relatively smooth with large areas bare of sculpture, foveae weak, often bounded by flat broad smooth areas. Elytral punctures well marked, not or only slightly increasing in size beyond the first few basal punctures. Punctures in adjacent striae similar sized, lateral interstriae occasionally granulate, interstriae not or only weakly raised particularly alternate interstriae toward apex, plica absorbed into interstria eight. Setae on head moderate to strong often present on pronotum as well, much of elytra setose. Pronotal epipleuron weak to moderate, 0.5 to 1.5 puncture widths wide, often poorly delineated. Pseudoepipleuron weak to moderate, elytral epipleuron absent behind, narrow in front. Front of mesosternum in middle with two weakly diverging longitudinal carinae, area between them moderately deep in front becoming very shallow behind. Profemur stout, basal pubescence weak to absent or virtually so ventrally. Mesofemur relatively stout to moderately elongate, narrowing towards base, basal pubescence moderate reaching end of trochanter or a bit past it on hind edge.

Male: Basal piece of aedeagus parallel sided or weakly constricted in middle, 1.6 – 2.0 times length of apical piece. Apical piece ranging from strongly dolphin-headed to almost smoothly triangular. Central lobe narrow reaching almost to tip of parameres (Figs 35, 36).

Distribution

Australian Capital Territory
25 km W Canberra, ANIC.

New South Wales
8 km N Bombala, SAMA; Kittys Crossing, ANIC; Monga, ANIC; Nerrigan, SAMA; Webers Creek, SAMA.

Northern Territory
33 km WNW Alice Springs, ANIC; Ellery Creek, NMV, SAMA; Ormiston Gorge, SAMA; Paisley Bluff, NMV; Simpsons Gap, SAMA; Standley Chasm, ANIC, SAMA: Vaughan Springs, SAMA.

Queensland
8 km N Bluewater, SAMA; Mary Creek 16°33S 145°12.5E, ANIC; Pentland, ANIC.

South Australia
Alligator Gorge, SAMA; Flinders Ranges, SAMA; Lucindale, QM; Mt Gambier, SAMA; 13 km W Meadows, SAMA; 1 km S Nangwarry, SAMA; Robe, SAMA; Williamstown, ANIC, SAMA.

Tasmania
8 km S Lake Leake, ANIC

Victoria
East Pomborneit, ANIC; Nathatia, SAMA; 4 km NNE Nelson, NMV; 5 km NW Portland, SAMA; Strathbogie, NMV; Tarra Valley, NMV; 6 km ENE Terang ANIC; 12 km SW Orbost, SAMA.

Western Australia

11 km E Ashburton Downs Homestead, WAM; Gill Pinnacle, WAM; 50 ml S Giles, WAM; Millstream, ANIC; 13 km ESE Mooka Station, WAM; 20 km NE Mt Sandiman, WAM; Murchison River, ANIC.

Remarks

Hydrochus horni is the southern counterpart of *H. obscuroaeneus,* occurring relatively commonly across southern Australia including semi-arid regions such as the Pilbara, Central Australia and the Flinders Ranges as well as more coastal regions of the South-east. It is also found, rarely, in Queensland as far north as the Atherton Tableland. It can be separated from *H. obscuroaeneus* by the more usually sized elytral punctures which, beyond the basal four to five, are subequal in size until nearing the elytron apex. Its clearest distinguishing character is the bare shiny areas on the pronotum of most specimens. (These are often absent on central Australian specimens.) Among group 3 species it tends to have the most elongate mesofemora with the greatest development of the basal pubescence. Both these characters occasionally approach the condition seen in some group 4 species. The weak basal pubescence on the profemur, the generally less elongate body, and strong development of dorsal setae separate it from any species in group 4.

Hydrochus granicollis resembles *H. horni* in many respects and is also sympatric with it in south-eastern Australia. *Hydrochus granicollis* tends to be a chunkier species, with a granulate pronotum without bare areas, has the apical punctures on the elytra often much larger than in *H. horni* and a more rounded apex to the elytra which often appears pinched in *H. horni.* The aedeagus of *H. horni* resembles that of *H. obscuroaeneus* with which it is sympatric in north Queensland. The two can be separated by the relatively smaller apical piece in *H. horni* (basal piece 1.6 – 2.0 times apical piece in length, in *H. horni*; 1.0 – 1.3 times in *H. obscuroaeneus*). Within *H. horni* there is a considerable degree of variation in the shape of the apical piece, although its comparatively short nature remains. In typical *H. horni* from central Australia the apical piece is particularly short and squat generally resembling the head of a dolphin. In other locations this shape is still present but other specimens tend to have the apical piece more elongated which has the effect of obliterating the dolphin-head shape and replacing it with the more usual triangular one in extreme cases. All intermediate shapes occur.

Hydrochus gitaraiae from Cape York and Arnhem Land closely resembles *H. horni*, particularly in the typical bare shiny areas on the pronotum, but is smaller and has a broader, differently shaped apical piece to the aedeagus.

Biology

Found at the edges of small rivers, creeks and ponds among stones and detritus.

Hydrochus numerosepunctatus sp. nov.

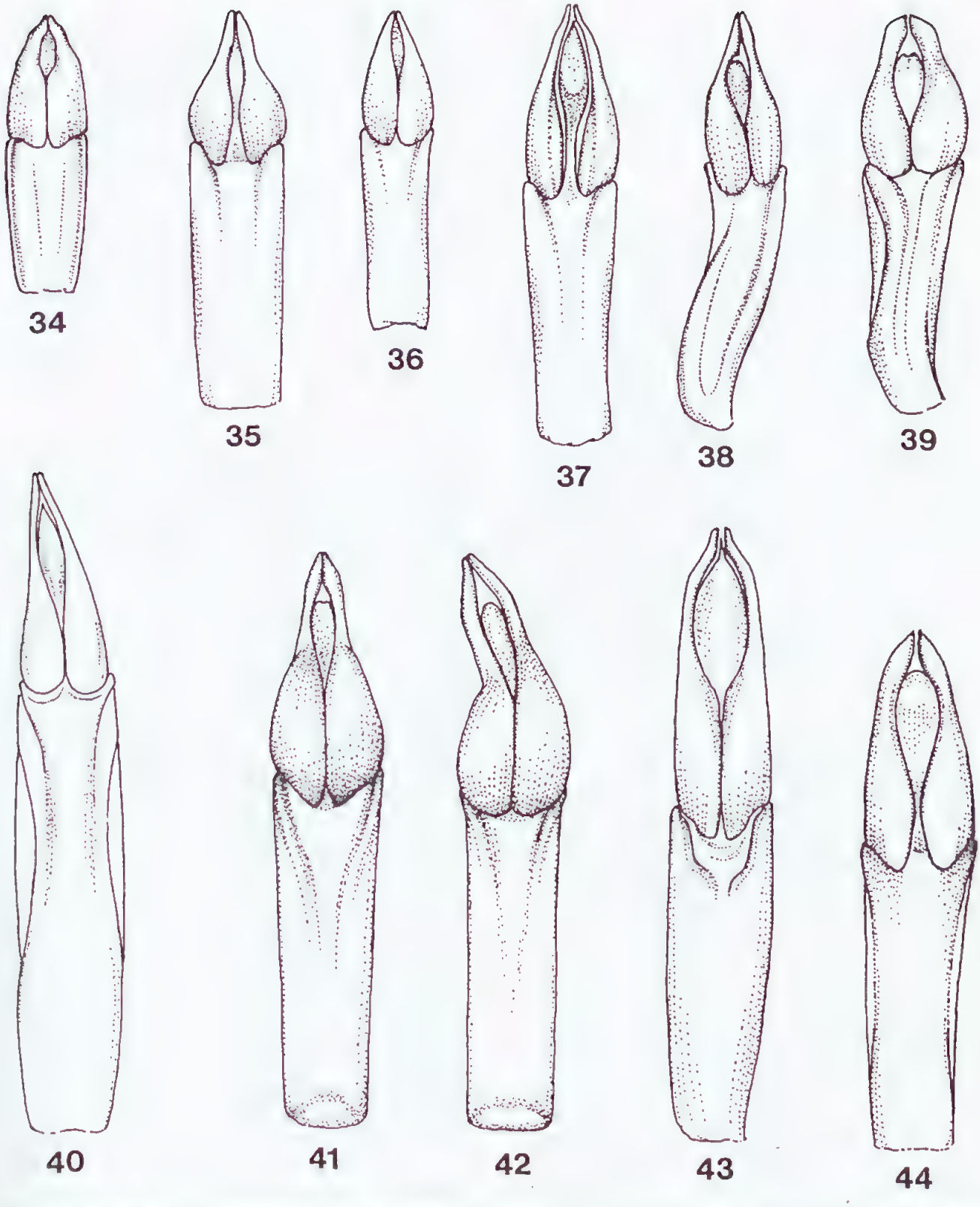
Types

Holotype: male, 'NT 1 km W Gubara Kakadu NP 17.3.98 C.H.S. Watts', SAMA.

Paratypes: 18, same data as holotype, SAMA; 10, 'AUSTRALIA: N.T. Kakadu NP Gubara 50 m. 25.10.1996 leg. L. Hendrich (1)', NHMW.

Description (number of specimens examined, 62) Fig. 30

Length 2.7 – 4.2mm. Elongate, elytra widest behind middle, quite rapidly narrowing to apex. Head shiny black, pronotum and elytra shiny dark brown to black; ventral surface dark red to black, legs testaceous, parts of tarsi, knees and much of femora darker. Head granulate/punctate, epicranial suture moderately impressed. Pronotum rugose, densely granulate/punctate, foveae weak to virtually absent. Elytra very deeply punctate, interstriae granulate to varying degrees, punctures in each stria increase in size toward middle from base and apex, punctures in adjacent stria same size or slightly larger from stria one to four. Alternate interstriae not or only weakly raised particularly toward apex and interstria eight. Plica absorbed into interstria eight. Pronotal epipleuron well marked about two punctures deep, fluted. Pseudoepipleuron moderate, elytral epipleuron absent behind, narrow in front, virtually invisible when elytra closed. Setae weak to very weak on elytron apex. Profemur moderately stout, basal pubescence weak, absent or virtually absent ventrally. Mesofemur relatively stout, narrowing somewhat toward base, basal pubescence weak, reaching approximately the end of trochanter on rear edge. Metafemur relatively stout, bowed on front edge. Front of mesosternum in middle with two longitudinal carinae, area between them deep in front becoming shallow behind. Metasternum evenly covered with relatively small (for *Hydrochus*) punctures not arranged in any pattern.



FIGURES 34–44 **34**, *H. gitaraiae*; **35–36**, forms of *H. horni*; **37**, *H. granicollis*; **38**, *H. aschnakiranae*; **39**, *H. kunarajahi*; **40**, *H. multicolor*; **41–42**, forms of *H. australis*; **43**, *H. abditus*; **44**, *H. radjiei*.

Male: Basal piece of aedeagus parallel sided 1.2 – 1.6 times length of apical piece. Apical piece bullet shaped, parameres rather regularly narrowing toward pointed tip. Central lobe moderately broad reaching to tips of parameres (Fig. 30).

Distribution

Northern Territory

Bamboo Creek near Wangi, NTM; Cooper Creek 19 km E by S Mt Borradaile, ANIC; 6 km SE Mt Borradaile, SAMA; 5 km SE Mt

Borradaile Station, SAMA; Gubara, Kakadu NP, NHMW, CLH, SAMA; 1 km S Gubara, Kakadu NP, SAMA; Holmes Jungle, NTM; 1 km S Jim Jim Falls, Kakadu NP, NHMW; Katherine Gorge, NTM; Koongarra, ANIC; Murganella, NTM; 6 km SW by S Oenpelli, ANIC.

Remarks

One of the largest of Australian *Hydrochus*, *H. numerosepunctatus* appears to be relatively common in coastal Northern Territory. It shows, with *H. obscuroaeneus,* the character of increasing size of elytral punctures from the elytral base to the middle. The species can be separated from most *H. obscuroaeneus* by its generally larger size (2.7 – 4.2mm against 1.8 – 3.0mm), deep but not particularly large elytral punctures, lack of pronotal fovea and granulate elytra. The male genitalia resemble those of some *H. obscuroaeneus* but the apical piece is relatively smaller. The numerous, evenly distributed, metasternal punctures are unique within Australian *Hydrochus,* although occasional specimens of other species may approach the condition seen in *H. numerosepunctatus.*

Biology

Little known, but appears to be associated with small creeks.

Etymology

Latin. 'many punctured' – in reference to the numerous punctures on the mesothorax.

Hydrochus obscuroaeneus Fairmaire

Hydrochus obscuroaeneus Fairmaire, 1879

= *Hydrochus palmerstoni* Blackburn, 1895; syn. nov.

= *Hydrochus insularis* Lea, 1926; syn. nov.

= *Hydrochus rodjani* Makhan, 1994; syn. nov.

= *Hydrochus wewalkai* Makhan, 1994; syn. nov.

Types

Hydrochus obscuro-aeneus Fairmaire. *Holotype*: not located, type locality given as Pt. Makay (?= Mackay), Queensland.

Hydrochus palmerstoni Blackburn. *Holotype*: female: 'T 3921 NT' 'Australia Blackburn Coll. B.M.1910–236' 'Hydrochus Palmerstoni, Blackb.', BMNH.

Hydrochus insularis Lea. *Lectotype*: male, 'insularis Lea TYPE Groote Eyl.' 'Groote Eylandt N.B.Tindale', SAMA. Herein designated.

Paralectotypes: 3, 'Groote Eylandt N.B. Tindale' 'Co-type' 'Griffith Collection Id by A.M.Lea', SAMA. Herein designated.

Hydrochus rodjani Makhan. *Holotype*: 'New Guinea Papua Brown River May 21,1956' 'E.J. Ford jr. Light trap', BPBM.

Hydrochus wewalkai Makhan. *Holotype*: male 'Australien 17.1.1993 Queensland Townsville 10m leg Wewalka (8)' 'Hydrochus wewalkai det D. Makhan 1994' with red Holotype label, NHMW.

Description (number of specimens examined, 162 dissected males) Figs 3, 31, 32, 33

Length 1.8 – 3.0mm. Moderately elongate, a little wider behind middle of elytra, elytral apex not greatly 'pinched'. Head black; pronotum dark brown-black with metallic tinges, extreme front margin often lighter; elytra dark testaceous to black; ventral surface dark brown to black, antennae and palpi testaceous, palpi usually with darker tips; legs light testaceous, parts of tarsi and knees darker. Head moderately to strongly punctate/granulate, epicranial suture moderate. Pronotum strongly punctate/granulate, foveae weak-quite strong, occasionally delineated by narrow raised areas. Elytra strongly sculptured, punctures well marked, very variable in size, relatively small to very large, those in each stria increasing in size towards disc from both base and apex of elytra, adjacent punctures in different striae approximately same size, weakly to moderately granulate, alternate interstriae, particularly numbers 4, 6 and 8 weakly to moderately raised for most of their lengths, plica absorbed into interstria 8. Weak to moderate setae on head and apical half of elytra. Pronotal epipleuron distinct, about two puncture widths wide, fluted. Elytron with relatively narrow pseudoepipleuron, epipleuron absent behind, very narrow in front half. Front of mesosternum in centre with two narrow carinae, area between them moderately deep. Profemur stout, basal pubescence weak, lacking or virtually so ventrally (Fig. 3). Mesofemur moderately elongated, weakly sinuate, narrowing slightly towards base, basal pubescence moderately developed not, or only slightly, extending beyond trochanter on posterior edge (Fig. 3). Metafemur moderately sized, weakly bowed on front edge.

Male: Basal piece of aedeagus parallel sided or narrowing towards base 0.8 – 1.3 times length of apical piece; parameres variable from narrowly triangular to quite broad, waisted and with rounded tip, central lobe variable from narrow to broad, only slightly shorter than parameres. There is considerable variation in the degree of elongation of the apical piece resulting in a corresponding variation in degree of constriction of parameres, expansion of the central lobe, narrowness of the parameres and the comparative length of the basal and apical pieces (Figs 31, 32, 33).

Distribution

Northern Territory

1 km SE Batchelor, SAMA; Barramundi Creek, Kakadu NP, SAMA, CLH, NHMW; Berry Springs, ANIC; Bessie Springs, ANIC; 11 km SW by S Borroloola, ANIC; 46 km SSW Borroloola, ANIC; 22 km WSW Borroloola, ANIC; 54 km S by W Borroloola, ANIC; 80 km SW Borroloola, ANIC; 5 km NNW Cahills Crossing, ANIC; 1 km N Cahills Crossing, ANIC; 8 km ESE Cape Crawford, ANIC; Coomalie Creek, CAL; Darwin, SAMA; Edith Falls near Katherine, CAL, ANIC; Gubara, Kakadu NP, NHMW, CLH, SAMA; 1 km W Gubara, Kakadu NP, SAMA; Gungurul Lookout, Kakadu NP, NHMW; Holmes Jungle, ANIC, SAMA; Howard Springs, NMV, ANIC, SAMA; Humpty Doo, DPIM; 10 km SW Jabiru, SAMA; 12 km E Jabiru, SAMA; Jim Jim Falls, NHMW, CLH; Katherine, ANIC; Koongarra, ANIC; Litchfield NP, NHMW; Magela Creek, ANIC; Manton Dam, ANIC; 19 km E by S Mt Borradaile, ANIC; 6 km SE Mt Borradaile, SAMA; 5 km SE Mt Borradaile Station, SAMA; 19 km E by N Mt Cahill, ANIC; 10 km E by N Mt Cahill, ANIC; 1 km NNW Mudginberry Homestead, ANIC; Naberlek Dam, ANIC; Nawurlandja, Kakadu NP, SAMA; Nourlangie Creek, ANIC; 18 km E by N Oenpelli, ANIC; 31 km SE by S Pine Creek, ANIC; South Alligator River, ANIC; South Alligator Inn, ANIC; South Johnston River, Old Jim Jim Road Crossing, SAMA; Tindal, NMV; Wildman River Lagoon, ANIC.

Queensland

Archer River, SAMA; Bloomfield, ANIC; Boggy Creek near Cooktown, ANIC; Burdekin River near Charters Towers, SAMA; Captain Billy Creek, SAMA; Cairns, CAL; Cape Tribulation, ANIC; 30 ml N Cape Tribulation, ANIC; Coen, MCZ; 60 km S Coen, SAMA; 40 km N Coen, SAMA; 21 km W by N Cooktown, ANIC; 29 km NW by N Cooktown, ANIC; Dalhunty River, SAMA; Dalrymple, 30 km N Charters Towers, NHMW; Giru, ANIC; 10 km SW by W Gordonvale, ANIC; Greenvale, NHMW; 70 km SW Greenvale, SAMA; Hann River, NMV; 7 ml N Hope Vale Mission, ANIC; Iron Range, ANIC; 7.5 km NNW Kuranda, DPIM, ANIC; Laura, DPIM; 73 km NW by W Laura, ANIC; 30 km N Laura, DPIM; 12 km N Laura, SAMA; 31 km NW by N Longreach, ANIC; 9.5 km SW Mareeba, DPIM; McIllwraith Ranges., SAMA; 1 km W Mingela, SAMA; 3.5 km SW by S Mt Baird, ANIC; Mt Garnet, SAMA; 40 ml SW Mt Garnet, CAL; 21 ml up Mt Lewis Road, DPIM; Mt Spec, ANIC; 11 km ENE Mt Tozer, ANIC; 2 km N Mt Tozer, ANIC; 9 km ENE Mt Tozer, ANIC; 3 km NE Mt Webb, ANIC; Peach Creek, SAMA; 11 km WSW Petford, DPIM; 1 km W Petford, SAMA; Reid River E of Mingela, SAMA; Rockhampton, CLH; Shiptons Flat, ANIC; Silver Plains, MCZ; Tolga, DPIM; Townsville, CAL, MCZ, NHMW; 10 km NW Townsville, SAMA; Thornton Range, ANIC; Walkamin, DPIM; Weipa, DPIM;

Western Australia

Carson Escarpment, ANIC; Drysdale River, ANIC; Gallery Hill, WAM; 14 km S by E Kalumburu Mission, ANIC; 4 km W King Cascade, ANIC; Millstream, ANIC; Mitchell Plateau, FIELD, ANIC; 3 ml SE Pago Mission, FIELD; Prince Frederic Harbour, ANIC; 2 km SW Rolly Hill, ANIC; Mitchell Plateau, ANIC; Synnot Creek, ANIC.

Remarks

A very common and widespread species in northern Australia. It shares, with *H. numerosepunctatus*, the character of the elytral punctures in at least the inner rows increasing in size until about the middle of the elytra. In other group 3 species (and most other Australian *Hydrochus)* the size of the elytral punctures increases rapidly from small to moderate within the basal one to four or five punctures and remaining approximately the same size until close to the apex. In *H. obscuroaeneus* the increase continues, albeit at a reduced rate well onto the elytral disc. The actual size of the elytral punctures is very variable from comparatively modest to extremely large.

Hydrochus obscuroaeneus can be separated from *H. numerosepunctatus* by the latter's

unusual punctation of the mesosternum. Most specimens of *H. numerosepunctatus* are also larger (2.7 – 4.2mm) than *H. obscuroaeneus* (1.8 – 3.0mm).

Hydrochus obscuroaeneus is unusually variable in both size of elytral punctures and in the shape of the aedeagus. However, study of over a thousand specimens, 162 of which were males with their aedeagi extracted, has convinced me that only one species is involved. I could detect no strong pattern in either character, with extremes of both occurring throughout its geographic range, except possibly a preponderance of specimens with strong punctures and wide, waisted aedeagi (Fig. 33) on Cape York. Nor is there any apparent linkage between puncture size and aedeagus shape. All intermediate shapes exist but the relatively weakly punctured elytra and thin elongate triangular-shaped aedeagi are by far the most common forms.

I have been a unable to trace the holotype of *H. obscuroaeneus* and base my identification on the brief description; primarily its small size, nondescript colour, large elytral punctures and locality.

The holotype of *H. palmerstoni* is a female and has moderately large elytral punctures; the lectotype of *H. insularis* has moderately sized elytral punctures and an aedeagus with a broad central lobe but the apical piece is not waisted (similar to Fig. 32); the holotype of *H. wewalkai* has slightly larger elytral punctures and a broad, weakly waisted, apical piece to the aedeagus. The holotype of *H. rodjani* is similar to that of *H. insularis* in elytral punctation and aedeagus. All of these fall within my concept of *H. obscuroaeneus.*

Biology

Most specimens have been taken among stones and vegetation at the edges of small rivers, creeks and ponds. Some specimens from Cape Tribulation in ANIC were collected from 'rainforest leaf & log litter'.

Species Group 4

Group 4 species are characterised by having: two rather than three longitudinal carinae at the front of the mesosternum; the mesofemur weakly spindle-shaped (Fig. 4); the pubescence at the base of the mesofemora usually reaching > a third the width of the femur at that spot along the rear edge; the basal pubescence on the profemora complete and reaching > a quarter the width of the femur at that spot along the femur. Other character states that help to define the group are: elongate; plain darkish in colour—although often with a slight metallic sheen; some interstriae may be weakly raised (in *H. multicolor* interstriae two and four are often strongly raised for part of their length); dorsal setae weak to moderate; pronotum with moderate to strong fovea; pronotal epipleura weak to moderate; head with weak epicranial suture.

Perhaps the most phylogenetically coherent group with most species only identifiable by the form of the aedeagus. *Hydrochus multicolor* stands a bit apart from the others.

They are the predominant group in southern Australia where they are often abundant but are also widespread and common in the north. They are still-water species most frequently found amongst emergent vegetation in relatively shallow water.

Hydrochus abditus sp. nov.

Types

Holotype: male, 'S. Aust Meadows 13 km W 35°11S 138°36E 28 Sept 96 C.H.S. Watts', SAMA.

Paratypes: 18, same data as holotype, SAMA; 14, 13 km W Meadows S.A. 26.9.98 C.H.S. Watts', SAMA.

Description (number of specimens examined, 50) Fig. 43

Length 2.4 – 3.5mm., Relatively broad, particularly elytra, widening slightly behind middle of elytra, narrowing apically. Dorsal surface black, ventral surface black, antennae and palpi testaceous, legs testaceous, parts of tarsi, knees and much of femora darker. Head with rather sparse large punctures, occasionally granulate; epicranial suture strongly impressed. Pronotum moderately punctate, granules absent or confined to sides; foveae weak, shallow, usually without raised margins. Elytral punctures relatively large; alternate interstriae not or only slightly raised; plicae weak. Setae on head moderate, often quite extensive over posterior half of elytra. Pronotal epipleuron well marked, relatively broad with strong vertically elongate punctures/grooves. Pseudoepipleuron moderately broad; elytral epipleuron absent posteriorly, enlarging anteriorly to about one quarter to one

third width of pseudoepipleuron in same position. Front of mesosternum in centre with two longitudinal carinae, the area between them rather shallow. Profemur with basal pubescence moderate, about one quarter width of femur ventrally. Mesofemur weakly narrowing towards base, basal pubescence well developed, about one third width of femur along posterior margin. Metafemur weakly bowed.

Male: Basal piece of aedeagus straight sided 1.1 – 1.3 times length of apical piece. Parameres thick in basal half, rapidly narrowing to a slim, weakly sinuate apical third. Central lobe wide, only a little shorter than parameres (Fig. 43).

Distribution

New South Wales

Armadale, ANIC; Congo, ANIC; 2 km N Batemans Bay, SAMA; 8 km N Failford, SAMA; MacLean, SAMA; 2 km S Nowra, SAMA; Royal National Park, CAL; Tamworth, CAL.

Queensland

North Pine River, MCZ; Yungaburra, MCZ.

South Australia

Adelaide, SAMA; 13 km W Meadows, SAMA; Myponga, SAMA; Williamstown, SAMA.

Tasmania

35 km E Hobart, NHMW; Launceston, QM; 40 km E Launceston, NHMW; 60 km E Launceston, NHMW; St. Helens, SAMA.

Victoria

11 km E Bruthen, SAMA; Cann River, ANIC; Dartmoor, SAMA; Ferntree Gully, SAMA; 4.5 km SW Healesville, FIELD; 4 ml NNE Nelson, NMV; 12 km SW Orbost, SAMA; Wyperfield NP, ANIC.

Western Australia

Millstream, ANIC; 1 km N Millstream, ANIC.

Remarks

A relatively common species in coastal southern Australia. Two other group 4 species are sympatric with it in southern Australia: *H. australis* and *H. multicolor*. *Hydrochus abditus* can be readily separated from *H. australis* by its broader shape, dark colour, weak elytral epipleura and by the greater development of the pronotal epipleura. *Hydrochus multicolor* differs from *H. abditus* by its usually strongly raised elytral striae, raised central panel on the pronotum and its usually iridescent dorsal sheen, in contrast to the shiny black of *H. abditus*. In northern Queensland I have been unable to reliably separate *H. abditus* from *H. kunarajahi*, *H. radjiei* and *H. aschnakiranae* other than by the male genitalia. In general it is larger, darker and with the elytra proportionally wider than the pronotum than in most *H. aschnakiranae*. From *H. radjiei* it has more weakly developed pronotal fovea and in general a smoother elytra. Specimens from the seemingly isolated population at Millstream in Western Australia are rather more strongly sculptured than others. I have found no characters that will help separate *H. abditus* from *H. kunarajahi* other than in the male genitalia.

Biology

A still water species found among vegetation in ponds or slow moving water.

Etymology

Latin. 'Hidden'–in reference to the species being 'hidden' within *H. adelaidae*.

Hydrochus aschnakiranae Makhan

Hydrochus aschnakiranae Makhan, 1994

= *Hydrochus schillhammeri* Makhan, 1995; syn. nov.

Types

Hydrochus aschnakiranae Makhan. *Holotype*: male, 'Solomon is. Guadalcanal: Roroni 35 km E of Honiara 10 m, 6.V1964' 'R. Straatman Light Trap', BPBM.

Hydrochus schillhammeri Makhan. *Holotype*: male, 'Australien QL (26) 10 km S Tully S Innisfail, 30 m 25.1.1993 leg Wewalka' 'Hydrochus schillhammeri det D. Makhan 1994' with red holotype label, NHMW.

Description (number of specimens examined, 117; dissected males, 38) Figs 4, 7, 38

Length 2.7 – 3.3mm. Elongate, subparallel, with elytra weakly expanded. Dorsal surface black shiny, elytra and pronotum a little lighter in some, ventral surface black, antennae and palpi dark testaceous, legs light testaceous with knees and parts of femora and tarsi darker. Head moderately punctate with weak flat granules, epicranial groove usually well marked. Pronotum with weak to moderate punctures, lacking granules; foveae shallow to moderate, usually delineated with weak

to moderately raised areas. Elytra with moderately large punctures, alternate interstriae tend to be raised, particularly four and eight, plica moderately strong. Head with weak to moderate setae, elytra with weak to moderate setae apically and on interstriae toward apex. Pronotal epipleuron moderate, about a puncture width wide. Elytron with moderately developed pseudoepipleuron (Fig. 7), epipleuron very narrow posteriorly, weak anteriorly where it is about one third the width of pseudoepipleuron. Front of mesosternum in centre with two longitudinal carinae, area between them relatively deep, shallower behind. Profemur stout, a little sinuate, basal area of pubescence relatively large, narrowest portion ventrally about a quarter width of femur at that point. Mesofemur elongate, weakly narrowing towards base; basal pubescence well developed, at narrowest ventrally about one third to one half width of femur at that point (Fig. 4). Metafemur relatively stout, anterior edge bowed.

Male: Basal piece of aedeagus 1.2 – 1.4 times length of apical piece, slightly to moderately twisted. Parameres rounded at base rather evenly narrowing to blunt tip, left hand paramere (ventral view) indented to accept tip of central lobe to greater degree than right hand one. Central lobe relatively narrow, shorter than parameres, with tip weakly expanded and weakly to moderately skewed to left (Fig. 38).

Distribution

Northern Territory

11 km SW by S Borroloola, ANIC; Canon Hill, Kakadu NP, SAMA; Cahills Crossing, ANIC; Coastal Plains Research. Station, ANIC; Coomalie Creek, CAL; Darwin, SAMA; 6 km E Humpty Doo, DPIM; 12 km E Humpty Doo, DPIM; Gungurul Lookout, Kakadu, NHMW, CLH; Kongarra, ANIC; Jabiluka Billabong, Kakadu, ANIC; Ja Ja Billabong near Mudginberry, ANIC; Jabiru, SAMA; 5 km NNW Cahills Crossing, ANIC; Mt Borradaile, SAMA; 6 km SE Mt Borradaile, SAMA; 5 km SE Mt Borradaile Station, SAMA; 8 km N Mt Cahill, ANIC; 19 km NE by E Mt Cahill, ANIC; South Alligator Inn, Kakadu, ANIC; Ubirr, Kakadu, NHMW.

Queensland

Archer Bend, SAMA; Annan River ANIC; 20 ml NW Ayr, CAL; 14 ml NW Ayr, CAL; Bundaberg, SAMA; Bushland Beach, 20 km N Townsville, SAMA; Caloundra, SAMA; Coen, DPIM, SAMA; 40 km N Coen, SAMA; 110 ml S Coen, NMV; 25 ml N Cooktown, ANIC; 8 km N Bluewater, SAMA; Home Hill, SAMA; Laura, SAMA; 12 km N Laura, SAMA; 50 ml W Mackay, ANIC; McIvor River 40 ml N Cooktown, UQIC; 1 km W Mingela, SAMA; 2 ml SW Mt Inkerman, ANIC; 2 km N Mt Molloy, SAMA; 10 km S Mt Molloy, SAMA; 3 km ENE Mt Tozer, ANIC; Musgrave, ANIC; 14 ml SE Normanton, ANIC, CAL; Reid River E of Mingela, SAMA; Rockhampton, ANIC, SAMA; Townsville, CAL, SAMA; 40 km S Townsville, SAMA; 20 km S Townsville, SAMA; 12 km NW Townsville, SAMA; 25 km S Townsville, SAMA; 40 km S Weipa, DPIM.

Western Australia

Mitchell Plateau, FIELD.

Remarks

A moderate-sized, dark species, separable from most *H. australis* by its weaker elytral epipleura, moderate pronotal epipleura and apparent lack of granules other than on front of head. Most *H. australis* have the pronotum and elytra lighter in colour than the head and often quite strongly so, whereas, apart from teneral individuals, *H. aschnakiranae* is uniformly black dorsally. The degree of pubescence on the femora is generally weaker than in *H. australis* but not enough to reliably separate the two. Separation of this species from *H. radjiei* and *H. kunarajahi* can only be done reliably from the aedeagus shape as outlined in the key.

Hydrochus aschnakiranae was described from Guadalcanal in the Solomon Islands but apart from the elytra and pronotum of the holotype being lighter in colour than in most Australian specimens I can't distinguish it from Australian material. (Makhan was mistaken in describing the colour of the head, pronotum and elytra of the holotype as black.)

I consider *H. schillhammeri* Makhan, described from a specimen from North Queensland, to be synonymous with this species. (Makhan's description of the type of *H. schillhammeri* is misleading: its colour is a shiny black, not green; the pronotum is uneven but to say it has ten large, deep depressions is far fetched; alternate elytral interstriae (2, 4, 6, 8 not 3, 5 & 8) are weakly raised but hardly carinate.)

Biology

Found amongst emergent vegetation in still or slowly flowing water. Taken at light.

Hydrochus australis Motschulsky

Hydrochus australis Motschulsky, 1860

= *Hydrochus parallelus* Macleay, 1873; syn. nov.

=*Hydrochus regularis* Blackburn, 1898; syn. nov.

= *Hydrochus diversiceps* Blackburn, 1898; syn. nov.

= *Hydrochus brunneonitens* Lea, 1926; syn. nov.

= *Hydrochus serricollis* Lea, 1926; syn. nov.

= *Hydrochus polaki* Makhan, 1994; syn. nov.

= *Hydrochus rambarani* Makhan, 1994; syn. nov.

Types

Hydrochus australis Motschulsky. *Lectotype*: 'Type' 'Pt Philip' 'Hydrochus australis Motsch Nov. Holl.' with yellow type label, ZMM. Two specimens now mounted on two cards on one pin, the upper specimen, a dissected male, herein designated.

Paralectotype: 1, same details as lectotype, lower specimen, herein designated, ZMM.

Hydrochus parallelus MacLeay. *Lectotype*: 'Hydrochus parallelus M.L.W. Gayndah' 'K 19664'. Left hand specimen of two mounted on one card, AM, herein designated,

Paralectotype: 1, same details as lectotype, right hand specimen, AM, herein designated.

Hydrochus regularis Blackburn. *Lectotype*: female, 'T 1532 V' 'Australia Blackburn Coll B.M. 1910–236' 'Hydrochus regularis, Blackb', BMNH. Herein designated. Blackburn mentioned a specimen from Murray Bridge (SA) and one from Western Victoria in the original description.

Hydrochus brunneonitens Lea. *Holotype*: female, 'brunneonitens Lea, TYPE Queensland', SAMA.

Hydrochus serricollis Lea. *Lectotype*: 'serricollis Lea TYPE Launceston', with 'TY' on card, SAMA. Herein designated.

Paralectotypes: 6, same data as lectotype, SAMA (*H. australis*);1, 'Lucindale S. Australia' 'Co-type' 'serricollis S. Australia Cotype', SAMA (*H. australis*); 2, 'Launceston' 'Co-type' 'Griffith Collection Id. by AM Lea', SAMA (*H. abditus*); 3, 'Davenport Tas: Lea' 'Tasmanian Towers' 'Griffith Collection Id by AM Lea' '14009 Hydrochus serricollis Lea Tasmania Cotype', SAMA (*H. australis*); 1, 'Strahan Tas: Lea & Carter' 'Hydrochus serricollis Lea Co-type' 'K 48448' 'Paratype', AM (*H. australis*); 2, 'George Town' 'K50043' 'Hydrochus serricollis Lea Co-type' 'Paratype', AM (?*H. abditus*); 1, 'George Town' 'Hydrochus serricollis Lea Co-type' a more recent Cotype blue label 'Paratype T-13212 Hydrochus serricollis Lea 1926', NMV (?*H. abditus*); 1, 'George Town' 'Paratype T-13213 Hydrochus serricollis Lea 1926', NMV (?*H. abditus*); 2, 'Launceston' 'Co-type' 'Hydrochus serricollis Lea, Co-type', QM (*H. abditus*); 2, 'Co-type' 'Launceston' 'Australia Brit Mus 1924-156' 'Hydrochus serricollis Lea, Co-type', BMNH (*H. australis*); 1, 'Co-type' 'Australia Brit. Mus.1924–156' 'East Tammar', BMNH (? *H. abditus*). Herein designated.

Hydrochus diversiceps Blackburn. *Holotype*: female, '6371 T' 'Albion Brisbane C. Wild. 17.7.92' 'Blackburn coll. 1910–236' 'Hydrochus diversiceps, Blackb.', BMNH.

Hydrochus polaki Makhan. *Holotype*: 'Coll. R.I.Sc.N.B. Australien Ex Coll. Weyers' 'Hydrochus polaki det. D. Makhan 1994' with red holotype label, IRSNB.

Hydrochus rambarani Makhan. *Holotype*: 'Coll. R.I.Sc.N.B. Australien N.S. Wales Coll Knisch Coll d'Orchymont' 'det Knisch parallelus' 'Hydrochus rambarani det. D. Makhan' with red holotype label, IRSNB.

Paratypes 3, same data as holotype, IRSNB.

Description (number of specimens examined, >1000) Figs. 6, 41, 42

Length 2.0 – 3.6mm. Elongate, relatively narrow and parallel sided or elytra weakly expanded. Head black; pronotum dark brown to black, sometimes with anterior margin lighter; elytra light testaceous to dark reddish brown; ventral surface black; antennae and palpi variably testaceous; legs light testaceous with knees, parts of tarsi, and sometimes parts of femora darker. Head and pronotum variably sculptured from smooth and weakly punctured to strongly granulate, pronotal foveae moderately developed, weakly delineated by raised areas. Elytral punctures moderate; interstria four may be weakly raised, plicae weak, granulation lacking to quite strongly developed. Pronotal epipleuron very narrow, virtually lacking in many specimens. Pseudoepipleuron moderate posteriorly, narrowing anteriorly; elytral epipleuron narrow, absent posteriorly, relatively broad anteriorly where it is equal in width or greater (usually) than pseudoepipleuron in same place (Fig. 6). Profemur stout, weakly

constricted at base, basal pubescence well developed, on ventral surface about half width of femur. Mesofemur moderately elongate, weakly narrowing towards base; basal pubescence well developed, reaching approximately the equivalent of the width of the femur along posterior/ventral margin. Metafemur moderately elongate, posterior edge straight, anterior edge evenly bowed, incomplete ventrally. Front of mesosternum in centre with two longitudinal carinae, area between them deep anteriorly but with weakly raised T shaped structure posteriorly. Head with weak to moderate setae; elytra with weak setae at apex and on some interstriae towards apex.

Male: Aedeagus with basal piece approximately five times as long as apical piece, parallel sided. Apical piece often twisted to left (viewed ventrally) to varying degrees; parameres bulbous in basal half, narrow and sinuate apically; central lobe narrow, slightly shorter than parameres (Figs 41, 42).

Distribution

Australian Capital Territory

Black Mt, ANIC; Canberra, SAMA; 30 km SW Canberra, SAMA; 25 km W Canberra, ANIC; Deakin, ANIC; Gungahlin, ANIC.

New South Wales

Armadale, ANIC; 8 km N Bombala, SAMA; Bulla Bulla Tank, SAMA; Clarence River, SAMA; Congo, ANIC; Cooma, SAMA; Coonabarabran, ANIC; 9 km NNE Coonabarabran, ANIC; 28 km N Dubbo, ANIC; Forbs, SAMA; Gilgandra, SAMA; Gindera, CAL; Hay, ANIC; 8 km W Hay, ANIC; 10 km W by S Jindabyne, ANIC; Lake Cowal, ANIC; MacLean, SAMA; Menindee Lake, ANIC, UQIC; Megalong Valley, MCZ; Mittagong, SAMA; 6 ml ESE Nelson Bay, ANIC; 20 ml W Nerringa, SAMA; Nyngan, CAL; Tumut River, CAL; 10 ml N Wagga Wagga, UQIC; Whitton, SAMA.

Northern Territory

Adelaide River, ANIC; Canon Hill, Kakadu NP, SAMA; Coastal Plains Research. Station near Darwin, ANIC; Darwin, SAMA; 15 km SW Elliot, SAMA; 2 km E Ja Ja Billabong, ANIC; 6 km N by E of Mudginberry, ANIC; Jim Jim Creek, ANIC; 8 km E Mt Cahill, ANIC; 18 km WSW Borroloola, ANIC.

Queensland

Alligator River, 20 km S Townsville, SAMA; Barcaldine, QM; 23 km NE Bauhina Downs, ANIC; Bushland Beach 20 km N Townsville, SAMA; Davison River, SAMA; Dalby, SAMA; Gayndah, SAMA; Gladstone, SAMA; Borumba Dam, NHMW, CLH; Brisbane, SAMA, NMV; Cardstone, ANIC; Cairns, QM; Condomine River, QM; Dawson River, QM; Emerald, QM; Goomeri, UQIC; Goondiwindi, SAMA; Greenbank, UQIC; 70 km SW Greenvale, SAMA; 15 km W Gympie, NMV; Hann River, DPIM; 10 km W Imbil, NMV; Inglewood, UQIC; Jarding Crossing, ANIC; Laura, SAMA; Kenilworth State Forest, UQIC; 13 km NW Lowood, UQIC; Mary Creek, ANIC; 14 km N Mt Molloy, ANIC; 50 km SW Mackay, ANIC; 8 km SW Mapleton, NMV; Moggill, QM; 21 ml S Miriam Vale, ANIC; Mt Borradaile, SAMA; 5.5 km SW by S Mt Biggenden, ANIC; Mt Garnet, SAMA, DPIM; 2 ml SW Mt Inkerman, ANIC; Oxley, QM; 10 km W Petri, SAMA; N Pine River, QM; S Pine River, QM; Rockhampton, SAMA, UQIC; 50 ml SW Rockhampton, ANIC; 29 ml SSW Rockhampton, ANIC; Taroom, QM; Townsville, SAMA, UQIC; 40 km S Townsville, SAMA; 25 km S Townsville, SAMA; 30 km SE Townsville, SAMA; Yeppoon, QM.

South Australia

10 km N Coonawarra, SAMA; Fairview Park Conservation Park, SAMA; Mannum, SAMA; Mt Gambier, SAMA; Mt Lofty, SAMA; Murray River, SAMA, UQIC; Murray Bridge, SAMA; 1 km S Nangwarry, SAMA; Naracoorte, SAMA; Penola, SAMA; Warradale, SAMA.

Tasmania

Deloraine, SAMA; Launceston, SAMA; Tooms River, ANIC.

Victoria

Ballan, NMV; 2 km W Brimpaen, SAMA; Buangor, SAMA; Cann River, ANIC; 12 km W Casterton, SAMA; Clines, NMV; Corryong, NMV; Dartmoor, SAMA; Dondangadale, NMV; Dromana, NMV; East Pomorneit, ANIC; Echuca, UQIC; 21 ml E Echuca, ANIC; Grampians, SAMA; Fyans Creek, SAMA; 7 km N Glenisla, SAMA; 5 km NW Halls Gap, SAMA; 3 km NE Hamilton, SAMA; Healesville, SAMA; 4.5 km SW Healesville, FIELD; 4 km SW Healesville, NMV; Inglewood, NMV; Jordon River, NMV; Lake Hattah, ANIC, NMV; Macallaster River, NMV; Melbourne, NMV; Merrijig, NMV;

Moyston, NMV; 10 km NE Mirranawa, SAMA; Mitchell Gorge, NMV; Nathalia, SAMA; Natya, NMV; 4 ml NNE Nelson, NMV; Nhill, NMV; 5 km NW Portland, SAMA; Ringwood, NMV; Stawell, SAMA; Swan Hill, NMV; 3 km SE Taggerty, NMV; 6 km E Terang, ANIC; Warrandyte, NMV; Wellington River, Werribee, NMV; Yarra River, NMV.

Western Australia

Armadale, SAMA; Belmont, FIELD; Boyup Brook, ANIC; Bridgetown, MCZ; Bunburry, ANIC; Darling Ranges, SAMA; 14 ml E Denmark, ANIC; Harvey River, NMV; Kerridale, ANIC; 4 km W King Cascade, ANIC; Maidavail, SAMA; Mandaring Weir, MCZ; Margaret River, NMV; Picton Junction, ANIC; Pinjarra, SAMA; 8 m E Pinjarra, ANIC; 6 km S Pinjarra, SAMA; Thomas River 101ml E Esperance, ANIC; Wilga, ANIC.

Remarks

Perhaps the commonest, most widespread and sculpturally variable of Australian *Hydrochus* which is reflected in the fact that it has been named seven times. If the variation in punctation/granulation of the dorsal surface is ignored the degree of variation is actually surprisingly little as I interpret the species. Most specimens are relatively distinctive, but some specimens, particularly from northern areas, may be inseparable from other species without dissection. Within group 4 it has the strongest pubescence on its legs and the widest elytral epipleura in contrast to the pseudoepipleura. No other group 4 species has the elytra lighter in colour than the head and pronotum, unless teneral. The weak to absent pronotal epipleura in *H. australis* also separates most specimens from related species, although some *H. abditus* also have weakly developed pronotal epipleura. In many specimens, particularly from more southern populations, the apical piece of the aedeagus is skewed sideways. Within Australian *Hydrochus* this character is shared only with *H. aschnakiranae* but in this species all specimens that I have seen have the aedeagus skewed to some degree whereas in *H. australis* there is considerable variation from straight to strongly skewed. In *H. australis* the parameres and the central lobe are equally skewed in contrast to *H. aschnakiranae* in which only the central lobe is skewed. (The type of *H. brunneonitens* is a teneral individual with a relatively light coloured dorsum and the darker colour on the legs apparently not yet developed.)

Biology

A very common species amongst emergent vegetation in still or slowly flowing water. Taken at light.

Hydrochus kunarajahi Makhan

Hydrochus kunarajahi Makhan, 1994.

Type

Holotype: male, 'AUSTRALIA: NQ Tulley Falls 111–10–1956' 'Light Trap J.L. Gressitt' 'Hydrochus kunarajahi det D. Makhan 1994', BPBM.

Description (number of dissected males examined, 21) Fig. 39

Length 2.7 – 3.5mm. Elongate, widening slightly behind middle of elytra. Head shiny black, pronotum and elytra shiny dark brown to black; ventral surface black; antenna and palpi testaceous, palpi tips darker; legs testaceous, parts of tarsi, knees and much of femora darker. Head moderately punctate/granulate, granules flat, epicranial suture distinct. Pronotum moderately punctate, foveae moderate, usually delineated by thin raised margins. Elytra with moderate sized but deep punctures, alternate interstriae not or only weakly raised, plicae moderate. Head and apical portion of elytra weakly to moderately setose. Pronotal epipleuron well marked, about a puncture width wide. Elytron with weak to moderate pseudoepipleuron, epipleuron absent to weak posteriorly, enlarging to one third to one half width of pseudoepipleuron anteriorly. Front of mesosternum in centre with two longitudinal carinae, area between then deep anteriorly, becoming shallower behind. Profemur weakly sinuate, basal pubescence well developed, ventrally about one quarter width of femur at same place. Mesofemur weakly sinuate, slightly narrower towards base, ventral pubescence well developed about one half to equal width of femur along posterior margin. Metafemur slightly bowed anteriorly.

Male: Basal piece of aedeagus narrowing towards base, about 1.5 – 1.7 times apical piece. Parameres bulbous, at base wider than basal piece, weakly narrowing in middle, slightly widening toward tip. Central lobe wide, about two thirds to three quarters length of parameres (Fig. 39).

Distribution

Northern Territory

14 km SW Cape Crawford, ANIC; 8 km ESE Cape Crawford, ANIC; Darwin, NMV; 19 km SSE Mataranka, ANIC.

Queensland

8 km N Bluewater, SAMA; Burdekin River E of Charters Towers, SAMA; 25 km N Laura, DPIM; Mary Creek 14 km N Mt Molloy, ANIC; Mackay, NMV; Reid River E of Mingela, SAMA; Rockhampton, NHMW, CLH; Townsville, CAL, FIELD.

Western Australia

12 km S Kalumburu Mission, ANIC.

Remarks

A relatively large, dark species very similar to *H. abditus*, *H. radjiei* and *H. aschnakiranae* but seemingly much rarer. From *H. aschnakiranae* it can be separated by the male genitalia (see key and Figs 38, 39). From *H. radjiei* it differs in having a weaker pronotal and elytral sculpture, and seemingly lacks the pronotal granules quite frequently found in *H. radjiei*. The male genitalia resemble those of *H. radjiei* and for a while I considered *H. kunarajahi* to lie within that species. They differ however in the narrowing towards the base of the aedeagus, the squatter apical piece and the strongly bulbous paramere bases (Fig. 39).

Biology

Found amongst stones, detritus and emergent vegetation at the edge of slow moving water. Taken at light.

Hydrochus multicolor Lea

Hydrochus multicolor Lea, 1926

= *Hydrochus matthewsi* Makhan, 1995; syn. nov.

Types

Hydrochus multicolor Lea. *Lectotype*: 'multicolor Lea TYPE Mt Macedon'. Right hand specimen of two mounted on one card and identified by 'TY' below it, SAMA, herein designated.

Paralectotypes: 1, same details as lectotype, SAMA; 1, 'Forest Reefs N.S.W. Lea' 'Co-type', SAMA; 1, 'Adelaide Blackburn' 'Co-type' 'C125', SAMA; 2, 'Mt Macedon Victoria H.W. Davey' 'Co-type', SAMA; 2, 'Mt Macedon Victoria H.W. Davey' 'F.E. Wilson Collection' 'Hydrochus multicolor Lea Cotype' with more recent blue label '2287-98 Cotype', NMV. Herein designated.

Hydrochus matthewsi Makhan. *Holotype*: male, 'Australien (19) Queensland Mareeba, 700m 22.1. 1993 leg Wewalka' 'Hydrochus jii det. D. Makhan 1994' with red Holotype label, NHMW. See note below.

Description (number of specimens examined, 78) Fig. 40

Length 2.7 – 4.4mm. Elongate, elytra weakly widened in middle, rapidly narrowing at apex. Head black, usually with iridescent sheen; pronotum dark brown to black usually with iridescence sheen; elytra dark-brown to nearly black shiny; ventral surface dark-brown, legs testaceous with parts of tarsi, knees and parts of femora darker. Head strongly granulate/punctate, granules often only at sides; epicranial suture weak to moderate. Pronotum rather smoothly granulate/punctate, foveae weak, the central third (longitudinally) of pronotum somewhat raised with sides falling away, almost flanged. Elytron with relatively small, even punctures, moderately to strongly granulate, interstriae two and six usually strongly raised in basal fifth, interstria four usually strongly raised from about level of end of raised portion of interstria two to the apical quarter, where the raised portion ends abruptly; interstria eight raised in basal three quarters incorporating plica. Head and elytra with none to a few setae. Pronotal epipleuron well developed, two to three puncture widths wide, sometimes fluted. Pseudoepipleuron moderately wide, epipleuron absent behind narrow in front. Front of mesosternum in centre with two narrow sharply raised longitudinal carinae, the area between them quite deep. Profemur moderately stout, basal pubescence moderately developed, about a quarter width of femur on ventral surface. Mesofemur elongate narrowing a bit toward base, basal pubescence moderately developed reaching about a quarter width of femur at base along hind ventral margin. Metafemur moderately elongate, weakly bowed on front edge.

Male: Basal piece of aedeagus narrow, straight sided, 1.7 – 1.9 times length of apical piece. Apical piece very narrowly triangular, pointed. Central lobe narrow, expanded a bit towards apex, a little shorter than parameres (Fig. 40).

Distribution

New South Wales

2 km N Batemans Bay, SAMA; 8 km N Bombala, SAMA; Collector, SAMA; Hartley Vale, MCZ; Megalong Valley, MCZ; Nyngan, SAMA.

Queensland

Mareeba, NHMW

South Australia

7 km N Forreston, SAMA; Inglewood, SAMA; 5 km NE Inglewood, SAMA; 13 km W Meadows, SAMA; Myponga, SAMA; Williamstown, SAMA.

Victoria

Ballan, NMV; 4.8 km WNW Blackwood, ANIC; Grampians, SAMA; Melbourne, NMV; 12 km SW Orbost, SAMA; Warrandyte, NMV.

Remarks

A large species from south-eastern Australia and the Atherton region of north Queensland. Well sculptured specimens are easily recognisable by the strongly raised elytral interstriae and the unusual raised central region of the pronotum, although this latter character is hard to describe adequately. In a few specimens the elytral interstriae are only weakly raised but even in these the abrupt ending to the raised portions is usually diagnostic. The aedeagus is distinctive and can only be mistaken for some group 2 species which are otherwise very different.

In NHMW there is a specimen collected by Wewalka from Mareeba, Queensland that has been labelled as the holotype of *Hydrochus jii* Makhan. This appears to be a *nomen nudum*. The locality data are identical to those given for the type of *H. matthewsi* Makhan. The male genitalia also match the illustration of *H. matthewsi* given by Makhan. Makhan's brief description would also match the specimen. Since I can find no trace of a labelled holotype of *H. matthewsi* I suspect this specimen is the holotype and I am treating it as such. It agrees with *H. multicolor* Lea in most aspects including aedeagus and pronotum. The elytral interstriae are much less strongly raised than in typical *H. multicolor* although within the variations found in this species. I consider it a junior synonym of *H. multicolor* Lea.

Biology

Found amongst emergent vegetation in still and slow moving water.

Hydrochus radjiei Makhan

Hydrochus radjiei Makhan, 1994

Type

Holotype: male, 'AUSTRALIA: NQ Tulley Falls 111-10-1956' 'Light Trap J.L. Gressitt', BPBM.

Description (number of specimens examined, 123: dissected males, 48) Fig. 44

Length 2.6 – 3.8mm. Elongate, widening slightly behind middle of elytra. Dorsal surface shiny, black, ventral black; antennae and palpi testaceous, palpi usually with dark tip, legs testaceous, parts of tarsi, knees and parts of femora darker. Head granulate/punctate. Pronotum with deep strong punctures, often granulate, foveae moderate to strong, bounded by narrow raised areas. Elytra with strong deep and regular punctures, alternate interstriae vary from weakly to quite strongly raised, plicae although strong tend to be absorbed into raised interstria eight. Head and apex of elytra weakly to moderate setose. Pronotal epipleuron well marked, about one puncture wide or a little wider. Pseudoepipleuron relatively narrow, elytral epipleuron absent to very narrow posteriorly, expanding anteriorly to one third to one half times the width of pseudoepipleuron in same place. Front of mesosternum in centre with two longitudinal carinae, area between them deep in front, becoming shallow in posterior half. Profemur stout, relatively parallel sided, basal pubescence about a quarter width of femur. Mesofemur rather narrow, weakly narrowing basally, basal pubescence strong, reaching one third to one half width of femur along posterior margin. Metafemur relatively elongate, weakly bowed on anterior edge

Male: Basal piece of aedeagus straight 1.4 – 1.7 times length of apical piece. Parameres thick, narrowing in middle, expanding towards tip, central lobe relatively thick, two thirds to three quarters length of parameres (Fig. 44).

Distribution

New South Wales

Maclean, SAMA; Yuragin NP, ANIC

Northern Territory

Adelaide River, ANIC; Berry Springs, ANIC; 46 km SSW Borroloola, ANIC; Coastal Plains Research Station, ANIC; Coomalie Creek, CAL; Cooper Creek near Mt Borradaile, SAMA; 52 km

S Darwin, ANIC; Groote Eylandt, ANIC; 12 km NE Howard Springs, ANIC; Humpty Doo, DPIM; 10 km SW Jabiru, SAMA; 20 km SSW Jabiru, SAMA; Katherine, ANIC; Koongarra, ANIC; Lake Bennet, NTM; Manton Dam, ANIC; 11 km SW by S Borroloola, ANIC; 6 km SE Mt Borradaile, SAMA; 19 km E by S Mt Borradaile, ANIC; 5 km SE Mt Borradaile Station, SAMA; 8 km E Mt Cahill, ANIC; 19 km NE by E Mt Cahill, ANIC; 8 km E Mt Cahill, ANIC; Muirella Park Kakadu, DPIM; Murganella, NTM; Pine Creek, SAMA.

Queensland

Archer Bend, SAMA; Archers Creek, ANIC; Ayr, CAL; Bamaga, SAMA, UQIC; Bowling Green Bay NP, SAMA; Bundaberg, SAMA; 8 km N Bluewater, SAMA; Caloundra, SAMA; Cape Flattery, ANIC; Cardstone, ANIC; 40 km N Coen, SAMA; Cooktown, ANIC; 25 km N Cooktown, ANIC; 14 ml NW; Dalhunty River, SAMA; Eubenargee Swamp, SAMA; Green Hills, ANIC; Hann River, DPIM; 10 km N Howard, NHMW, CLH; 7 km N Hope Vale Mission, ANIC; Iron Range, ANIC, UQIC; Mackay, NMV; 40 ml N Cooktown, UQIC; Mt Molloy, SAMA; 9 km ENE Mt Tozer, ANIC; 73 km NW by W Laura, ANIC; 25 km N by W Mareeba, ANIC; Mary Creek, ANIC; 20 ml N Maroochydore, ANIC; Mission Beach, ANIC; Mt Webb NP, ANIC; 3 km NE Mt Webb, ANIC; 5 km ESE Mt Finnigan, ANIC; 17 km N Mt Molloy, ANIC; 52 km SW by S Mt Garnet, ANIC; Rockhampton, NHMW, SAMA; 15 km WNW South Johnstone, DPIM; Strathmore Station, DPIM; 3 km ENE Mt Tozer, ANIC; 2 km NNE Mt Tozer, ANIC

Western Australia

Mitchell Plateau 14°49S 125°50E, ANIC; 3 ml E Pago Mission, FIELD.

Remarks

A relatively large, dark species which is common in coastal northern Australia. Although most specimens can be separated from *H. australis* by colour and weaker elytral epipleura not all can, in which case dissection is required. It is even more similar to *H. aschnakiranae*, but tends to be larger and more robustly sculptured, often with granules on the pronotum which are lacking in *H. aschnakiranae*. Again reliable separation should be based on the male genitalia. These vary a bit in the degree of elongation of the apical piece, and extremely elongated examples can be confused with *H. aschnakiranae*, but *H. radjiei* lacks the twisted basal piece, the asymmetric parameres and narrower skewed central lobe of *H. aschnakiranae*. (The male genitalia of the holotype appear to have the central lobe distorted and not to be naturally skewed: see figure in Makham, 1994). At the other extreme *H. aschnakiranae* aedeagi can approach those of *H. kunarajahi* (see discussion under that species).

Biology

Found amongst emergent vegetation in still and slow moving water. Taken at light.

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CHECKLIST OF AUSTRALIAN *HYDROCHUS* LEACH

H. abditus sp. nov.
H. adelaidae Blackburn
H. aenigmatis sp.nov.
H. aschnakiranae Makhan
H. atratus sp. nov.
H. australis Motschulsky
H. brunneonitens Lea = *H. australis* Motschulsky
H. burdekinensis sp. nov.
H. cucullatus sp.nov.
H. decorus sp.nov.
H. diversiceps Blackburn = *H. australis* Motschulsky
H. eurypleuron sp.nov.
H. gitaraiae Makhan
H. granicollis Lea
H. horni Blackburn
H. imamkhani Makhan
H. insularis Lea = *H. obscuroaeneus* Fairmaire
H. interioris Blackburn
H. kunarajahi Makhan
H. lateviridis Blackburn
H. macroaquilonius sp.nov.
H. matthewsi Makhan = *H. multicolor* Lea
H. multicolor Lea
H. nadesui Makhan = *H. obscuroaeneus* Fairmaire
H. numerosepunctatus sp.nov.
H. obscuroaeneus Fairmaire

H. obsoletus Lea
H. palmerstoni Blackburn = *H. obscuroaeneus* Fairmaire
H. parallelus MacLeay =*H. australis* Motschulsky
H. polaki Makhan = *H. australis* Motschulsky
H. radjiei Makhan
H. rambarani Makhan = *H. australis* Motschulsky
H. regularis Blackburn = *H. australis* Motschulsky
H. rodjani Makhan = *H. obscuroaeneus* Fairmaire
H. scabricollis Lea = *H. horni* Blackburn
H. schoenmanni Makhan = *H. imamkhani* Mahkan
H. schillhammeri Makhan = *H. aschnakiranae* Makhan
H. serricollis Lea = *H. australis* Motschulsky
H. simplicicollis Lea
H. umbratilis sp.nov.
H. verae Makhan = *H. simplicicollis* Lea
H. victoriae Blackburn = *H. adelaidae* Blackburn
H. wewalkai Makhan = *H. obscuroaeneus* Fairmaire

References

ANGUS, R. B. 1977. A re-evaluation of the taxonomy and distribution of some European species of *Hydrochus* Leach (Col., Hydrophilidae). *Entomologists Monthly Magazine* **112**: 176–201.

BLACKBURN, T. 1888. Notes on Australian Coleoptera with descriptions of new Species. *Proceedings of the Linnean Society of New South Wales* **3**: 805–875.

BLACKBURN, T. 1895. Further notes on Australian Coleoptera, with descriptions of new Genera and Species. *Transactions of the Royal Society of South Australia* **19**: 27–60.

BLACKBURN, T. 1896. Coleoptera (exclusive of the Carabidae) *in* 'Report of the Horn Scientific Expedition to Central Australia', Part II–Zoology: 254–263. Melville, Mullen and Slade: Melbourne.

BLACKBURN, T. 1898. Further notes on Australian Coleoptera, with descriptions of new species. *Transactions of the Royal Society of South Australia* **22**: 221–233.

FAIRMAIRE, L. 1879. Descriptions de Coléoptères nouveaux ou peu connus du Musée Godeffroy. Hydrophilidae. *Journal du Museum Godeffroy* **XIV**: 80–83.

LEA, A. M. 1926. Notes on some miscellaneous Coleoptera with descriptions of new species Part VI. *Transactions of the Royal Society of South Australia* **50**: 45–84.

MACLEAY, W. 1873. Notes on a collection of insects from Gayndah. *Transactions of the Entomological Society of New South Wales* **2**: 29–205.

MAKHAN, D. 1994. Thirty-five new *Hydrochus* species from the Old and the New World (Coleoptera; Hydrophilidae). *Annales Historico-Naturales Musei Nationalis Hungarici* **86**: 29–42.

MAKHAN, D. 1995. Descriptions of ten new species of *Hydrochus* from different parts of the world (Coleoptera: Hydrophilidae). *Phegea* **23**: 187–193.

MOTSCHULSKY, V. 1860. Reise und Forschungen im Amur-Lande in den Jahren 1854–1856 von Dr. Leopold v. Schenck, 2 (2), Coleopteren, Imperial Academy of Science: St. Petersburg.

OLIVA, A. 1995. The genus *Hydrochus* Leach (Coleoptera; Hydrophiloidea; Hydrochidae) in South America, with special reference to Argentina. *Bulletin et Annales de la Société Royale Belge d'Entomologie* **132**: 301–341.

SMETANA, A. 1988. Review of the family Hydrophilidae of Canada and Alaska (Coleoptera). *Memoirs of the Entomological Society of Canada* **142**: 316pp.

DESIGNATION OF A LECTOTYPE AND DESCRIPTIONS OF FOUR NEW SPECIES OF AUSTRALIAN BUPRESTIDAE (COLEOPTERA).

SHELLEY BARKER

BARKER, S. 1999. Designation of a lectotype and descriptions of four new species of Australian Buprestidae (Coleoptera). *Records of the South Australian Museum* 32(1): 45–49.

A lectotype is designated for *Cisseis nubeculosa* Germar. The following four new species of Buprestidae are described: *Cisseis ernestadamsi* sp. nov., *Cisseis robertfisheri* sp. nov., *Astraeus acaciae* sp. nov., *Neocuris carnabyae* sp. nov.

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Material

Specimens examined came from the following institutions and collections:

ANIC — Australian National Insect Collection, CSIRO, Canberra.

BMNH — The Natural History Museum, London.

HUMB — Humboldt University Museum, Berlin.

MHSA — Mr T. M. S. Hanlon, Hunters Hill, Sydney.

MPWA — Mr M. Powell, Melville, Western Australia.

SAMA — South Australian Museum, Adelaide.

Introduction

Cisseis and *Ethon*, closely related genera in the tribe Agrilini (Coleoptera: Buprestidae), were proposed by Gory and Laporte (1839). Subsequently Blackburn (1887) separated *Neospades* from *Cisseis* on the basis of the structure of the tarsi and their claws described as double in *Neospades* and single in *Cisseis (s.s.)*. Examination of available material has shown that there is a gradation in the tarsal claws from one condition to the other and *Neospades* should be delimited by other characters or abandoned. Carter (1923) was the last reviser of *Cisseis* which now needs to be re-examined. *Cisseis* species are difficult to identify and all of the types need to be examined before a revision can be completed. It is now known that the genus occurs in Australia, New Guinea and nearby islands and in the Philippine Islands. In Australia the genus is largely, but not exclusively, associated with *Acacia* species.

The location of the Germar types of *Cisseis* in the Humboldt University Museum, Berlin has been established and I have examined the types of *Cisseis nubeculosa* Germar, *Cisseis chalcoptera* Germar and *Cisseis notulata* Germar, all collected in Adelaide. The first two are female and male specimens respectively of the same species, common in South Australia. The third is an uncommon species confined to South Australia as far as I know. Two new species of *Cisseis* were discovered by veteran collectors: the first in Queensland by Mr E. E. Adams, beetle collector extraordinaire; the second in South Australia by Mr R. H. Fisher, well known butterfly expert. Herein I name both species to honour their collectors.

Astraeus is a well known genus in which more than half the species are associated with *Allocasuarina* species (Barker 1975; 1977; 1989). Thus it is unusual that a new species has been found in Western Australia associated with *Acacia*, the first record of an association between the two genera. On the other hand *Neocuris* is poorly known and difficult to identify. The group has not been revised for over seventy years (Carter 1928) and there is no reliable key for their identification. A very distinctive species has come to hand from a remote locality in Western Australia and is described herein.

Designation Of Lectotype

I have examined two female syntypes of *Cisseis nubeculosa* Germar (HUMB no. 42752) and two male syntypes of *Cisseis chalcoptera* Germar

(HUMB no. 42752) all collected in South Australia (Germar 1848) and held in the Humboldt University Museum, Berlin. These specimens all belong to the same common species which is confined to South Australia. Thus *C. chalcoptera* Germar is a synonym of *C. nubeculosa* Germar. I have placed a fluorescent red label with the following handwritten words: LECTOTYPE, *Cisseis nubeculosa* (Germar), selected S. BARKER 1998, on the pin of one of the two female syntypes. I hereby designate this specimen as the lectotype of *C. nubeculosa* Germar.

Descriptions Of New Species

Cisseis ernestadamsi sp. nov.
(Fig. 1A)

Types

Holotype: ♂, ii.1946, Edungalba, Qld, on brigalow, E. E. Adams, ANIC. *Allotype:* ♀, summer 1975/76, Separation, Qld, leg. A. Smith, E. E. Adams, SAMA I21 406. *Paratypes:* Qld. 3 ♀♀, xii.1945, Mourangee, Edungalba, E. E. Adams, ANIC; 1 ♀, same data as holotype, ANIC; 1 ♀, 1969, Edungalba, 80 km SW (sic) of Rockhampton, E. E. Adams, ANIC; 1.xii.1973, Mr Emlen, Milmerran, J. McQueen, ANIC.

Colour

Head and antennae coppery. Pronotum coppery with green reflections. Scutellum green or coppery with green reflections. Elytra dull green with coppery reflections; irregularly spotted with clumps of white pubescent setae. Ventral surface dull green, much of the sternum covered with dense white pubescent setae, abdomen with thick white pubescent setae laterally. Legs dull green.

Shape and sculpture

Head flat, deeply punctured, moderately setose; interocular width 0.6 of maximum head

FIGURE 1. Habitus illustrations of the following *Cisseis* species. **A**, *C. ernestadamsi* sp. nov. **B**, *C. robertfisheri* sp. nov. Scale bar = 5mm.

width, dense pubescence around ventral margins of eye and lateral to the mouth. Antennomeres: 1–3 obconic; 4–11 triangular. Pronotum shallowly punctured medially, striolate and with irregular foveae laterally; anterior margin straight, basal margin sinuate; dorsal carina diverging from ventral carina at base for short distance, then more or less parallel until again diverging towards anterior margin which it reaches, space between deeply punctured and with some pubescence in well preserved specimens. Scutellum scutiform, anterior margin rounded, flat with punctures. Elytra heavily scutellate with small, stiff clumps of setae scattered more or less evenly over the whole surface. Ventral surface shallowly punctured, setae sparse medially, clumped and pubescent laterally. Legs: tarsal claws with inner tooth; hind tibial comb from middle to apex with three rounded projections.

Size

Male, 13.0 x 4.5 mm (1). Females, 14.7 x 5.0 mm (7).

Remarks

This species is closest to *C. niveosparsa* Carter and has been misidentified as that species. It can be distinguished by its green colour, *C. niveosparsa* is brown; it is a larger species; male genitalia are reasonably similar but not identical. It was collected on *Acacia harpophylla* F. Muell, ex Benth., brigalow, at all localities.

Etymology

This species is named after its collector Mr E. E. Adams, Edungalba, Queensland.

Cisseis robertfisheri sp. nov.
(Fig. 1B)

Types

Holotype: ♂, Melrose, S. Aust., 1.iii.1986, R. H. Fisher, SAMA I21 407. *Allotype:* ♀, Melrose, S. Aust., 23.i.1978, R. H. Fisher, SAMA I21 408. *Paratype:* S. Aust.: ♂, same data as holotype, SAMA.

Colour

Head, antennae, pronotum, scutellum dark green. Elytra black with spots formed from clumps of white pubescent setae. Ventral surface dark green with lateral white spots formed by pubescent setae. Legs dark green.

Shape and sculpture

Head deeply punctured, deep anterior median fovea, interocular width 0.6 maximum head width. Antennomeres: 1–3 obconic; 4–11 triangular. Pronotum shallowly punctured medially, deeply punctured laterally; anterior margin projecting slightly medially, basal margin sinuate; dorsal carina not meeting ventral carina posteriorly, diverging for short distance then more or less parallel, not reaching anterior margin, space between punctured and covered with squamiform setae. Scutellum scutiform, the sides extended laterally, flat, without punctures. Elytra with numerous white spots formed by clumps of pubescent setae, the eight largest arranged in a circular pattern, with a number of smaller inner and outer spots including one on each side at the basal margin. Ventral surface shallowly punctured medially, scutiform laterally; with dense lateral clumps of pubescent setae. Legs: tarsal claws with small inner tooth; hind tibia with setal comb from just before middle to apex in three distinct clumps.

Size

Males, 12.0 x 4.1 mm (2). Female, 13.5 x 5.0 mm (1).

Remarks

All specimens were collected on *Acacia victoriae* Benth. The species most resembles *C. leucosticta* Kirby (holotype BMNH) but can be separated from that species by the dark green colour of the head and pronotum which are bronze-green or coppery in *C. leucosticta;* the elytra which are black in *C. robertfisheri* and brown or bronze in *C. leucosticta;* and the male genitalia which are narrower and parallel-sided in *C. robertfisheri* and wider and rounded in *C. leucosticta.*

Etymology

This species is named after its collector Mr R. H. Fisher, Adelaide.

Astraeus acaciae sp. nov.
(Fig. 2)

Types

Holotype: ♂, Wooramel R., W.A., on *Acacia* sp., 23.ix.1980, S. Barker & D. J. Williams, SAMA I21 409. *Allotype:* ♀, 11 km S Billabong roadhouse, W.A. on *Acacia sclerosperma,* 7.ix.1996, M. Golding & M. Powell, WAMA.

FIGURE 2. Habitus illustration of *Astraeus acaciae* sp. nov. Scale bar = 5mm.

Paratypes: 1 ♂, same data as allotype, MPWA; 3 ♂♂ & 1 ♀, 11 km S Billabong roadhouse, W.A., 9.ix.1996, M. Golding & M. Powell, MPWA; 3 ♀♀, 1 ♂, 11 km S Billabong roadhouse, W.A., 11.ix.1998, T. M. S.Hanlon MHSA; ♂, 11 km S Billabong roadhouse, 11.ix.1998, M. Golding & M. Powell, MPWA.

Colour

Head black with purple reflections. Antennae black with blue-green reflections. Pronotum black with purple reflections. Elytra black with blue and purple reflections and the following pale yellow markings: elongate basal spot almost reaching basal margin; pre-medial fascia, concave forwards touching margin but not reaching suture; post-medial fascia, concave backwards touching margin reaching little more than half way to suture; elongate pre-apical spot. In one of the specimens in the type series there is an elongate, narrow spot between the two fasciae close to but not touching the suture. Ventral surface black with blue and purple reflections. Legs black with blue-green reflections. Setae silver.

Shape and sculpture

Head closely punctured; with small apical median keel; setose. Antennae: males with antennomeres more or less equal in length; females with antennomeres progressively decreasing in length towards apex. Pronotum closely punctured; laterally rounded and narrowed from base to apex; small basal crypt at apex of medial lobe, setose. Elytra costate, intervals flat and smooth, each interval with row of punctures; parallel-sided from base, rounded posteromedially and tapered to sharp marginal spine; sutural spine sharp, rounded inner margin; humeral fold moderately developed, angled (*vide* Barker 1975 Fig. 1C). Ventral surface shallowly punctured, moderately setose, setae short.

Size

Males, 8.7 x 3.5 mm (7). Females, 9.1 x 4.1 mm (5).

Remarks

In my revised key to *Astraeus (s.s.)* (Barker 1989 p. 191) this species keys out at 18. Add: 'Short, compressed species.... *A. acaciae* Barker.'

Etymology

This species is named for its association with *Acacia sclerosperma* F. Muell.

Neocuris carnabyae sp. nov.
(Fig. 3)

Types

Holotype: ♂, Coral Bay, W.A., 9.ix.1974, K. & E. Carnaby, ANIC. *Allotype:* ♀, same data as holotype, ANIC. *Paratypes:* W.A.: 6 ♂♂, Coral Bay, 8.ix.1974, K. & E. Carnaby, ANIC; 5 ♂♂ & 2 ♀♀, same data as holotype, ANIC & SAMA; 1 ♂, 112 km S Onslow, 28.viii.1971, T. F. Houston, SAMA.

Colour

Male. Head and antennae green with yellow reflections. Pronotum blue-green medially, green laterally with yellow reflections. Scutellum green.

FIGURE 3. Habitus illustration of *Neocuris carnabyae* sp. nov. Scale bar = 5mm.

Elytra green surrounding scutellum and along suture for short interval; green at margin at the level of the interval between second and third coxae; elsewhere dark blue except for yellow marking in the form of a central X, the arms completely connected in some specimens and not in others. Ventral surface and legs green. Setae silver.

Female. Head and antennae blue. Pronotum and scutellum dark blue. Elytra same markings as in male but blue replaces green. Ventral surface blue, legs royal blue. Setae silver.

Shape and sculpture

Ovoid. Head shallowly but closely punctured with medial sulcus. Antennomeres: 1–2 obconic; 3–11 triangular. Pronotum shallowly but closely punctured; projecting medially from apical margin, basal margin bisinuate; laterally rounded and narrowed from base to apex, a few punctations each with central sensillum. Scutellum scutiform, without punctures. Elytra shallowly punctured, humeral callus prominent, apically rounded and subserrate. Ventral surface with shallow punctures.

Size

Males, 5.8 ± 0.08 x 2.5 ± 0.04 mm (12). Females, 6.5 ± 0.32 x 2.8 ± 0.15 mm (3).

Remarks

The elytral markings most closely resemble those of *Neocuris ornata* Carter, a Queensland species in which the pale markings take the form of a W. The head and pronotum of that species are bright metallic green.

Etymology

The name honours the collector Mrs Edith Carnaby of Wilga.

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References

BARKER, S. 1975. A revision of the genus *Astraeus* Laporte & Gory (Coleoptera: Buprestidae). *Transactions of the Royal Society of South Australia* **99**: 105–142.

BARKER, S. 1977. *Astraeus* (Coleoptera: Buprestidae); A description of three new species and new locality records. *Transactions of the Royal Society of South Australia* **101**: 11–14.

BARKER, S. 1989. Contributions to the taxonomy of Australian Buprestidae (Coleoptera): New species of *Astraeus* and *Stigmodera (Castiarina)* and a key to *Astraeus* (*s.s.*). *Transactions of the Royal Society of South Australia* **113**: 185–194.

BARKER, S. 1998. Selection of lectotypes and redescriptions of three *Cisseis* (Coleoptera: Buprestidae) species. *Records of the South Australian Museum* **31**: 21–23.

BLACKBURN, T. 1887. Further notes on Australian coleoptera with descriptions of new species. *Transactions of the Royal Society of South Australia* **10**: 177–287.

CARTER, H. J. 1923. Revision of the genera *Ethon, Cisseis* and their allies (Buprestidae). *Proceedings of the Linnean Society of New South Wales* **48**: 159–176.

CARTER, H. J. 1928. Revision of the Australian species of the genus *Curis, Neocuris* and *Trachys,* together with notes and descriptions of new species of other Coleoptera. *Proceedings of the Linnean Society of New South Wales* **53**: 270–290.

GERMAR, E. F. 1848. Beiträge zur Insektenfauna von Adelaide. *Linnaea entomologica* **3**: 153–247.

GORY, H. & LAPORTE, F. L. 1839. 'Histoire naturelle et iconographie des insectes coléoptères, publiée par monographies séparées.' Volume **2,** livraisons 25–35. P. Duménil: Paris.

WAIYUNGARI AND HIS RELATIONSHIP TO THE ABORIGINAL MYTHOLOGY OF THE LOWER MURRAY, SOUTH AUSTRALIA

PHILIP A. CLARKE

CLARKE, P. A. 1999. Waiyungari and his relationship to the Aboriginal mythology of the Lower Murray, South Australia. *Records of the South Australian Museum* 32(1): 51–67.

The ethnographic record of Aboriginal mythology in the Lower Murray cultural region of South Australia is dominated by accounts of male ancestral heroes, particularly Ngurunderi, Waiyungari and Nepeli. The analysis of the ethnographic accounts of the Waiyungari mythology in this paper gives greater understanding of the cultural landscape and provides further insights into local Aboriginal perceptions of the seasons and of their cosmos. A critique of writers who have drawn upon the Waiyungari mythology for popular work is included. Here is a study of cultural geography, focusing upon the interaction between culture and the physical landscape.

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Introduction

The available literature on Aboriginal mythology in the Lower Murray contains many apparently conflicting accounts of major ancestors, such as Waiyungari.[1] The mythological corpus of south-eastern Australia derives its broad defining character from a number of congruent local variations, as previously noted in the case of the eaglehawk and crow (Blows 1975) and Ngurunderi myths (Clarke 1995). Although the literature for the Lower Murray acknowledges the importance of Ngurunderi in establishing particular traditions and creating many topographical features, the significance of events attributed to Waiyungari has been treated as secondary. This paper follows previous work that discusses how Aboriginal mythology provides an image of the dynamic aspects of cultural relationships to landscape (see Berndt & Berndt 1989: 408–427; Bos 1988; Charlesworth 1984: 383–387; Clarke 1991a: 66–69, 1995, 1999; Rose 1988). The investigation of the Waiyungari myth is an important vehicle for the study of Aboriginal cosmological beliefs in the Lower Murray region. In this myth are explanations of the seasonal changes that Aboriginal people observed in their landscape. Similarly, their social lives were considered by them to be subject to some of the forces that generated the seasons. In the early years when Europeans commenced mainland settlement, the Lower Murray cultural region could be defined as the area bounded by Rapid Bay in the west, across to the southern side of Murray Bridge, and south to Kingston (Fig.1). This takes in the southern part of the Fleurieu Peninsula, all of Encounter Bay, Lake Alexandrina and Lake Albert, and the Coorong.[2] The region includes territories occupied by dialect groups, such as the Ramindjeri, Tangani and Yaraldi-speaking people, who are each in turn represented by a number of smaller descent groups. The Lower Murray region was essentially a single cultural bloc, with strong connections to the north east. The cultural geography of the Aboriginal people associated with this region is discussed in detail by Clarke (1994, 1995, 1997).

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[1] There are many versions of this name in the literature, such as Waijungngari (Meyer 1846); Wyungare (Taplin 1874 [1879]; Smith 1930; Mountford 1971); Waiungare (Taplin 1879); Waiongari (Mathew 1928: 530); Waiangari (Tindale 1934–37); Waijungari (Tindale 1935); Waijunggari (Harvey 1939 MS); Wyungarre (Roheim 1971: 292); and Wyungara (Reed 1980). This paper uses the spelling Waiyungari, as used by Meyer (1843) and Berndt & Berndt (1993). Similarly, the spellings of the names of other spirit ancestors, Ngurunderi and Nepeli, follow the standards used by Berndt & Berndt (1993) and Clarke (1995).

[2] The placement of the northern boundary of the Lower Murray cultural region at Rapid Bay reflects Aboriginal movements after European settlement, as described by Tindale (1934–37: 41), the Berndts (1993, map 10, p.330) and Clarke (1991: 66–69). Prior to the 1830s, this boundary was east of Cape Jervis (see Amery 1998: 66).

FIGURE 1. The Lower Murray cultural region (after Clarke 1994).

The Sources

The Dresden missionary, Heinrich A. E. Meyer (1843), first recorded the Waiyungari mythology from the Raminyerar (Ramindjeri people) of southern Fleurieu Peninsula in the early nineteenth century. Later, versions were recorded predominantly from Yaraldi people of the area around the eastern side of Lake Alexandrina and surrounding Lake Albert. During the late nineteenth century, accounts of Waiyungari appeared in scholarly papers and newspaper articles by the Aborigines' Friends Association missionaries George Taplin (1874, 1879) and his son Frederick Taplin, who were based at Point McLeay on the Narrung Peninsula on the shore of Lake Alexandrina.[3] The Christian influences on their records is significant and has been commented upon elsewhere (Clarke 1994: 64, 65, 247–252, 418, 419; 1995: 146, 150–153; 1997: 125–127). Laurie (1917) published another account of Waiyungari in the form of a reminiscence from an early pastoralist C. J. Hacket of the Narrung Peninsula area. The Aboriginal sources for the versions mentioned so far are not recorded, nor are the transcripts of exactly what the recorders were told. As ethnographic sources, there is no way to ascertain how literal the translation was and whether the recorders, unwittingly or deliberately, introduced their own new elements into the mythology.

In the twentieth century, with the advantage of the development in fieldwork techniques within the discipline of anthropology, a number of

[3] There is a suggestion that G. Taplin's records are a blending of Ramindjeri and Yaraldi data. Initially he engaged English-speaking Ramindjeri people to help to elicit information from Yaraldi people at Point McLeay (see Taplin Journals 5 May 1861). Taplin also used the Meyer (1843) Raminyerar dictionary as a basis for his own work (Taplin Journals 10 April 1859; Clarke 1994: 247, 418, 419). G. Taplin (1879: 50,51) obtained the account of the Tanganarin group at Goolwa from police trooper T. Moriarty. Other references include G. Taplin (*Register*, 30 January 1862) and F. Taplin (*Register*, 24 April 1889). The F. Taplin data appears to be based on that of his father, G. Taplin.

researchers investigated aspects of pre-European Aboriginal cultures in southern South Australia. This period of ethnographic recording produced a number of accounts of the Waiyungari mythology. In the 1930s, Museum curator Norman B. Tindale (1934–37; 1935) recorded two major versions of the mythology while working with a Tangani-speaking man Clarence Long (Milmendjeri descent group, northern Coorong area) and a Yaraldi-speaking man Frank Blackmoor (Peltindjeri descent, near Point Sturt).[4] The social anthropologists Ronald M. and Catherine H. Berndt (1993) worked in the late 1930s and early 1940s, recording aspects of Yaraldi culture. They obtained information from Aboriginal people such as Mark Wilson (Liwurindjeri descent group, eastern Narrung Peninsula), Albert Karloan (Manangka descent group, eastern Narrung Peninsula) and Pinky Mack (Piltindjeri descent group, Poltalloch Station, Lake Alexandrina). Some of the accounts provided by Tindale and the Berndts are accompanied by transcripts and sound recordings of what was said by their Aboriginal sources. For this reason, and because of a more rigorous scientific approach, their material is more useful than the nineteenth century data for ethnographic reanalysis, with less likelihood of the recorders making errors in formulating their written versions. Another field worker, Alison Harvey (1939 MS), recorded supplementary data from various Lower Murray people in 1939. A more detailed evaluation of the biases of each of these sources is given elsewhere (Clarke 1994, 1995, 1997). Popular writers have used these base texts in their own compilations. An analysis of these is provided in a later section of this paper.

The Ethnographic Accounts

The account recorded from the Raminyerar by Meyer (1846: 201, 202) is not tied to a particular part of the landscape, although appears to refer to a coastal region. A brief overview is as follows. The mother of Waiyungari was Ningarope, and his older brother was Pungngane. Ningarope gave birth to Waiyungari in the form of 'excrement' that was red due to menstruation. This colouring gave Waiyungari the status of *kainjani* (*kaindjani*, initiate) from birth. Pungngane, who had a normal birth, lived with his two wives near the sea. Pungngane's wives found Waiyungari asleep in his hut one day. They attracted his attention by imitating the noise of an emu and seduced him.[5] Ningarope was angry at the behaviour of the women and informed Pungngane what had happened. Pungngane searched for his wives and brother, but found the hut deserted. He placed a fire upon the hut and told it to burn later when Waiyungari and the wives were asleep. During the evening the fire increased and started to fall on the skins of the occupants, forcing them to run to the sea. From a position of safety, Waiyungari wondered how he could escape his brother's wrath. Waiyungari threw a spear into the sky, which made contact but fell to earth again. He then used a barbed spear that he sent skyward with all his force. It remained stuck and was used by Waiyungari and the wives to climb into the sky. Pungngane and Ningarope saw them there and followed. Waiyungari was recorded in the Ramindjeri dialect as meaning the 'name of a star' (Meyer 1843 (2): 105). The Raminyerar attributed the abundance of kangaroo and *pondi* (Murray cod, *Maccullochella peeli*) to the actions of Pungngane and Waiyungari. Pungngane caught a *pondi* and divided it into small pieces, each of which, when thrown into the sea, became another *pondi*.[6] Apparently Waiyungari increased the number of kangaroos in a similar way.

The main accounts of Waiyungari recorded by Taplin (1874 [1879: 55–58]; 1879: 38, 39) are geographically located around the Point McLeay Mission Station on the Narrung Peninsula. According to Taplin, Waiyungari had a mother (not named), a brother called Nepeli, but no father.[7] Waiyungari and Nepeli, along with Ngurunderi, were great hunters. Waiyungari was particularly renowned for hunting kangaroos. Both Waiyungari and Nepeli pegged out the skins

[4] Tindale (1931: 189,211–219; 1938–56: 79–107) also recorded a version of Waiyungari in Yaraldi language from Albert Karloan. He never translated this.

[5] Roheim (1971: 292) interpreted this incident in Meyer's account as meaning that the women were 'emu wives of the All-Father', a possible link to the native companion and emu story of south-eastern Australia (see Tindale 1931–34: 207–209; 1938–56: 33–61).

[6] The fish creation episode is similar to that recorded for Ngurunderi (Clarke 1995: 148). Meyer recorded *pondi* as *ponde*.

[7] In the 1874 version by Taplin, there is no stated relationship between Waiyungari and Nepeli. In the 1879 account, Taplin states they are brothers. In most other ways the accounts are similar.

of kangaroos, which formed the many salt lagoons in the area (see Fig.2). Waiyungari once tore a large kangaroo into many pieces, thus creating smaller kangaroos.[8] It was Ngurunderi and Nepeli who performed the division of fish. A mound of limestone, called Pulluwewal (Pullawewal), on the Narrung Peninsula was perceived by local Aboriginal people to be the hut of Waiyungari. Waiyungari lived at Rauwoke (hill at Point McLeay) with his mother. He had been a 'red man' from his infancy. Once, whilst drinking water through a reed at Oulawar on the lake, Nepeli's two wives saw him and fell in love with Waiyungari.[9] Together they waited until he was asleep and made a noise like two emus running past. Waiyungari yielded to their demands and took them as wives. When Nepeli learned of this he was angered and went looking for his brother and his wives, but found Waiyungari's hut vacant. Nepeli placed a fire in the hut and told it to wait until Waiyungari and the wives were asleep inside and then burn them. The flames from the burning hut chased the occupants along the lakeshore until they reached Lowanyeri at Lake Albert Passage, where they escaped into the mud. Waiyungari decided to live in Wyirrewarre (Skyworld), away from Nepeli's hatred. He threw a spear with a line attached into the sky. Although it stuck, it would not hold Waiyungari's weight. He had more success with a barbed spear, pulling himself up and then hauling up the women. In Taplin's time three stars, which he did not identify, were still pointed out by local Aboriginal people as Waiyungari and the wives. From the hill of Rauwoke, Nepeli placed his canoe in the heavens, forming the dense part of the Milky Way. Then he went skyward in the same manner as Waiyungari.

Taplin (1879: 50, 51) published a small account of Waiyungari obtained from the 'Goolwa clan'. The police trooper T. Moriarty had recorded it on a survey return. In this version, Ngurunderi had two wives (not named) who caught two fish: a large fish, which they baked for themselves, and a small one that was given to their husband. This attempt at concealment made Ngurunderi angry. He punished all people of the local group, called Tanganarin, by giving them death and taking away their knowledge. As a result, the Tanganarin became 'like beasts in the field'. Ngurunderi left them and went up to the sky. Taplin (1879: 51) records that 'After a long time there was born of a virgin a good and wise man, who was named Wyungare [Waiyungari].' This man was a 'great teacher' who gave back much of what the Tanganarin had lost, and also taught them sorcery. Ngurunderi eventually took Waiyungari up to the sky where he became 'the second king of that place'. When a Tanganarin person died, Waiyungari took their spirits up into the sky and found them a country to live in.

Under a section titled 'The Translation of Heroes', Mathew (1928: 530) provides a brief overview of Lower Murray mythology based upon an interview with a Ngarrindjeri man, David Unaipon.[10] He says:

> Nurunderi [Ngurunderi], the reputed ancestor of the Narrinyeri [Ngarrindjeri], came down the Darling, and then down the Murray, where he and his followers displaced a tribe that were dwelling there, whose leaders were Neppele [Nepeli] and Waiongari [Waiyungari], the latter being a nephew of Neppele. These two were ultimately translated to the sky and became with their wives, the stars in the tail of Scorpio (Mathew 1928: 530).

And Ngurunderi 'drove away Neppele and Waiongari who had possessed the country before him' (Mathew 1928: 536). This account clearly establishes an antagonistic relationship between Ngurunderi and Nepeli and Waiyungari.

In 1934 Tindale (1934–37: 32–36, 64) recorded a version of the Waiyungari mythology from Clarence Long, a Tangani man with connections to the Coorong and the Upper South East. Although obtained from a Tangani informant, the sites involved are clearly within the descent group territories of the Yaraldi dialect region. In Long's

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[8] In the 1879 version, Taplin assumes that the tearing apart of fish and kangaroos was designed to make them smaller. A more likely explanation was that the ancestors were increasing the abundance of the food. Roheim (1971: 292) gives other examples of ancestors increasing the numbers of animals and people by tearing apart larger spirit beings.

[9] The act of drinking through a reed is a clear indication that Waiyungari was an initiate. Taplin (1874 [1879: 17]) claims that this was the practice for youths made *kaingani* (*kaindjani*, sacred initiate status), and adds that they were not allowed to use drinking vessels for several months. Harvey (1939 MS) was told by Pinky Mack that Lower Murray 'men during initiation have to drink water from a reed: not allowed to touch water with their feet.' Howitt (1904: 674), Tindale (1935: 267), Berndt (1974: 26) and Berndt & Berndt (1993: 177–178) noted this practice amongst Lower Murray people.

[10] The source of Mathew's Lower Murray data is not stated as David Unaipon in his paper (1928). P. G. Jones (pers. com.) claims that this was the case.

account, Waiyungari and his elder brother, Nepeli, lived with their elderly mother at an unspecified place on Narrung Peninsula. Nepeli was an 'old man' (fully initiated?) about to marry two women from another group, when his mother took Waiyungari to Pullawewal to avoid trouble. Nepeli's wives were not told that he had a younger brother. On one occasion, all the men went down to Waintjang where Yoldi (ancestral shag man) was camped with other bird men. Here Waiyungari was being covered with ochre and made a young man. Yoldi had red rubbed on to his chin and on his mainly grey chest through holding Waiyungari while ochre was put on him. Jungundjeri (pronounced Yungunderi?) was a reddish bird that lived in the reeds, and it was he who actually applied the ochre. Nepeli's wives were curious about what was happening. Waiyungari was in the habit of going to Ngawulwara (Ngulawar, Woodrow Point near Narrung) to drink and swim in Lake Alexandrina. Nepeli forbade his wives to go in this direction, restricting them to Wangaroka (Wangarawar, Taplin's Landing). One day, when Nepeli was asleep, the wives wanted a change of food, desiring to eat fresh-water mussels. They had strayed past Wangaroka when they saw red ochre floating in the water, which was due to Waiyungari swimming nearby. The women followed the ochre trail back through the reeds and eventually found his camp at Pullawewal where he lived with his mother. The two women tricked Waiyungari to come out by imitating an emu. Waiyungari wanted to get some emu meat to send down to the little reed bird (presumably the one involved in his initiation). The two women lured him away and seduced him. The mother, who had earlier heard Waiyungari leave the camp, told him that he should have kept away from the women. She left Waiyungari and went to tell Nepeli. The 'old man', Nepeli, sneaked upon Waiyungari's camp to kill him and the women with fire.[11] Waiyungari and the wives escaped to Tembatung (an inland hill on Narrung Peninsula), where they watched the camp burn. They knew of Nepeli's anger as they could see his spear shining. Because of their shame, the Rekkaldi people at Ngararang (the town site Narrung) would not look at them. Waiyungari and the wives made a reed raft and crossed the Lake Albert Passage and walked into the mallee scrub. At Komantuk (the town site Coomandook), Waiyungari tried to spear the sky but he was not high enough. They travelled further to Mulgarap-ngawan (the place Cold and Wet near Mount Boothby). Waiyungari 'sang' the spears: the first went nearly out of sight into the sky, and then the second struck the first. The third spear had a 'hair line' attached, and when thrown it struck the others. Waiyungari tightened the line by attaching the free end to a 'waddy' (club). Waiyungari and the women climbed up into the sky where they can be seen as stars. When Nepeli had lost his wives, he made another one from the flowering stem of a *ngalaji* (grasstree flower stem, *Xanthorrhoea* species) at Retjeri (bluff at Point McLeay).[12] He went down to the edge of the lake to secure his canoe and he saw the flowering stem of *pantaruki* (ribbon weed, *Triglochin procerum*). This was a pretty plant that took his fancy, so he made a second wife out of that. Nepeli now had two wives again.

In Tindale's published Yaraldi version of this myth (1935), which Frank Blackmoor gave him in 1934, Waiyungari was the brother of Nepeli, who in turn was the brother in-law to Ngurunderi. His mother created him from her own 'red excrement'.[13] The red colour meant that he was instantly *narambi* (sacred). Nepeli and his two wives lived at Ngulawar[14], while Waiyungari lived at Pulaweiwalth (Pullawewal). One day Nepeli's two wives went to Wangarawar (Wangaroka, Taplin's Landing) which was near the camp of Waiyungari at Pullawewal. Waiyungari was at Wangarawar also, drinking water through a reed stem. This was the 'watering place' of the youth whilst undergoing initiation and young women

[11] Although Nepeli controlled the use of fire, its introduction in the creative period was attributed to events surrounding Kondoli the whale (Meyer 1847:203–204; Berndt & Berndt 1993:235–236,450–451).

[12] Information on plants provided in the 'Tanganekald Vocabulary Cards' (no date) compiled by N.B. Tindale, Anthropology Archives, S.A. Museum. The grass tree flower stems were used by Aboriginal people in the Lower Murray region as a source of edible nectar when in season, and were used as firesticks when dry (Clarke 1986:11; 1994: 175). Both the grass tree and the ribbon weed have edible tubers (Clarke 1988: 69–70; 1994: 175).

[13] It is not clear whether this is menstrual blood or faeces.

[14] In Taplin's version, Ngulawar appears as Oulawar. A note by Tindale (on a copy of his 1935 paper in the reprint file, Anthropology Archives, S.A. Museum) says 'Note by Milerum [Clarence Long] 13.5.36. Ngulawar is name for any lookout hill; this one is really Retjerawar ie. the Bluff at Pt McLeay.'

were forbidden to go near there. He was a *kaindjani* (initiate) and therefore covered with red ochre and emu oil and was not to be seen by women. Ochre fell from Waiyungari's body and that made the water red. The two women watched Waiyungari in secret and followed him back to his camp. They forced Waiyungari out of his hut by mimicking emus, and then grabbed him by the penis and seduced him. Nepeli, upon discovering the involvement of his wives with Waiyungari, seized a fire-stick and some grass, and hid this above the hut. He told the fire to burst into flame when Waiyungari and the two wives snored. When this happened, they fled through the scrub towards the Lake Albert Passage, with the fire following them. The kangaroo skins, dropped as they fled, were transformed into a line of salt pans, which remain today as a marker of their flight. At Malbindjerang, on the western side of Narrung Passage, they were forced into the mud and for a time were safe there. After the fire, Waiyungari looked about for a means of escape. He threw a spear towards the sky, but this fell back. Then he threw another, which lodged there. As a result, the sky fell downwards towards the terrestrial landscape. Reaching up to his spear, Waiyungari climbed into the sky. He found it to be 'good ground' and so asked the two women to follow him. They remained in the sky as three stars, the central one being Waiyungari.

The records of Harvey (1939 MS) briefly mention an event surrounding Nepeli, Waiyungari and the wives. She writes that her informants, Creighton Unaipon (Potawalin people, Wellington area) and Jacob Harris (Mungkarrulp people, Tatiara district), told her that 'Pulawaiwal [Pulluwewal]' is a 'hill back of Mission where Nepelle saw his two wives follow Waijunggari'. Harvey also provides another account of how Nepeli gained two more wives after the others went into the Skyworld with Waiyungari. She records that 'Nepelle turned a grass-tree into a woman on Thornley's place [at the south-eastern side of the Narrung township] by touching it. Touched Jew lizard (*manuartiki* [*Amphibolurus barbatus*]) and it turned into a woman.' Both pieces of information from Harvey vary from other accounts in detail, although they are structurally similar to Tindale's version from Clarence Long.

The account provided by the Ronald and Catherine Berndt (1993: 191,228–231, 317, 341, 366–367, 400, 442–444) from Yaraldi people is similar to that of Tindale. A detail the Berndts make explicit is that Waiyungari was living in total seclusion as an initiate. He was the younger brother of Nepeli and their two sisters were the wives that Ngurunderi chased. The two wives of Nepeli were returning to their camp after having been out diving for mussels at Yawaiperung (site on the shore of Lake Alexandrina), when they noticed that the ground at Puleweiwald (hill of Pullawewal) was red from the red-ochred Waiyungari. The women were attracted to him. Waiyungari was also willing to break the rules and sleep with the wives. Nepeli found them and set the fire trap. After escaping the fire, Waiyungari and the wives of Nepeli crossed the lake, regaining the land at Yaltung (site on the south-western side of Lake Albert Passage) and fled to the Sky to avoid punishment. This was achieved by climbing on a string composed of spears, which Waiyungari used to drag the sky down. Waiyungari, because of his red covering of ochre, became identified as the planet Mars. He and Nepeli's wives sit in Ngurunderi's Canoe (Milky Way), with Waiyungari's spears alongside. The emu constellation is nearby in the west.

The Cultural Importance Of Waiyungari

The data for all of south-eastern Australia suggests that there was a definable 'set' of dominant ancestors, often described as 'Supreme Beings', who are male, and whose personae or identities overlap from region to region.[15] These dominating figures originated from outside the local cultural area and their point of origin was always obscure. Their travels through the region provided the main founding drama of the society, defining cultural and geographical boundaries, and setting limits to social action. In the process the dominant ancestors encountered people and other spirit beings already living in the area, even if, like Nepeli, they may also have been traceable in their origins beyond the cultural region. Waiyungari is one such local being – he is born in the country and most of his actions, before leaving for the Skyworld, take place there. He is therefore not classed as a 'Supreme Being'.

[15] In the recorded mythology of south-eastern Australia such male 'supreme beings' include Baiame, Bunjil, Waku, Korna, Nepeli, Nurelli and Ngurunderi. For an overview of these ancestors see Berndt (1974) and Clarke (1995).

The name of Waiyungari refers to his relationship to the Skyworld, which was called Waiyuruwar.[16] There were also other spirit beings, other than the major creators, that the Lower Murray people closely associated with the Skyworld. For example, there is the myth of the 'dream man' Kulda, who came out of the Southern Cross to prepare people for death and to take their spirits to the Land to the West (see Clarke 1997:137). The ethnographic sources of south-eastern Australia contain many examples of ancestors, of greater and lesser importance, who finished up in the sky (Howitt 1904: 488–508; Mathew 1928: 528–531; Eliade 1958: 41–43; Berndt 1974: 24–30). In Lower Murray culture the male ancestors, such as Waiyungari and Ngurunderi, were more prominent in their beliefs than the totem-protectors (*ngatji*) tied to specific descent groups (Berndt 1974: 26; Berndt & Berndt 1993: 243). Although described as 'ancestors', these male beings stand apart from the kinship system.

The predominance of 'Supreme Beings' in the Aboriginal mythologies of south-eastern Australia appears to have been reinforced by interaction with Europeans. There are some clearly Christian influences in the recorded Lower Murray mythology (see Clarke 1995: 150, 152). For instance, Taplin's account of Waiyungari from the 'Goolwa clan', which is blended with the Ngurunderi mythology, appears to have appropriated elements from the Old and New Testament. The acts of a Supreme Being punishing people by giving them death, his forgiveness, together with the birth of a great teacher from a virgin indicate direct Christian influence. Swain (1993, chapter 3) suggests that in south-eastern Australia it was the European colonisation process that generated Aboriginal world views dominated by 'high gods'. Full treatment of the 'high god' debate is beyond the scope of this paper (see Morton 1994: 904–95; Hiatt 1996: 100–119). Nevertheless, it has been previously suggested that the smallpox epidemic that struck southern South Australia just prior to official settlement in 1836 would have devastated local Aboriginal populations and possibly led to some adjustment to cultural practices (Clarke 1995: 145).

The sealers also would have had an impact upon the world views of the coastal Aboriginal people with whom they interacted (Clarke 1995: 145; 1996: 56–59,65–70; 1998: 24–28). The earliest official accounts concerning the Aboriginal inhabitants often occurred some twenty years after the arrival of the first Europeans. These records are therefore of a culture that was coming to terms with European contact. Furthermore, realignment of Aboriginal mythology may well have occurred in the 1880s during the last initiatory sequence in southern South Australia, which was attended by Aboriginal groups from widespread areas.[17] To what extent 'high gods' existed in south-eastern Australian cultures prior to Aboriginal experience with non-Aboriginal people will never be known for certain. Nevertheless, there is a possibility that the rapid demise of Aboriginal population on the frontier significantly enhanced the importance of their beliefs in certain ancestors, particularly those associated with death, living in the Skyworld. The intensive contact between Aboriginal people and European colonists in the Lower Murray region favoured the development of syncretic traditions.

The events of the Waiyungari myth were said to have occurred during early spring, a season recognised by Yaraldi speakers as *riwuri*, running from August to October (Berndt & Berndt 1993: 76, 229–231). This was a time of growth and mating. The illicit involvement of Waiyungari with women was perceived as causing poor fishing initially, but improving upon the arrival of the Young Men (Orion) and Women (Pleiades) constellations in September (Berndt & Berndt 1993: 164). Waiyungari was said to disappear in October-November at the onset of *luwadang*, the time of warmth. According to the Berndts, Waiyungari was symbolic of spring: 'witness his hot-bloodedness, his personification as the red planet, his role of a contravener of the law ... he was responsible for all natural growth' (Berndt & Berndt 1993: 230). There were no rituals for the renewal of seasons or species, apart from the pervasive influence of Waiyungari (Berndt & Berndt 1993: 75). Waiyungari's 'original mythic act of coitus with Nepeli's wives symbolised the propagation of all species – he made possible their recurrent renewal through copulation' (Berndt &

[16] See Clarke (1991, 1997) for a discussion of the Skyworld concept.

[17] Berndt & Berndt (1993: 163–185,) describe the last initiation sequence in the 1880s at which Lower Murray people were present. Clarke (1995: 151) comments on the impact of widespread participation of Aboriginal groups from south-eastern South Australia, the Mid North of South Australia and adjacent parts of Victoria and New South Wales.

Berndt 1993: 75). This was strongly supported by text translated from Yaraldi that was recorded from Karloan (Berndt & Berndt 1993: 341). Waiyungari's appearance in the sky was a marker for Lower Murray people of the arrival of the breeding seasons of animals and the beginning of the growth period for many economically important plants. In contrast, Ngurunderi was described by the Berndts (1993: 76, 230) as symbolic of winter (*yutang* – cold season from May to July): his actions had set the scene for the later events involving Waiyungari. In the case of autumn (*marangalkadi* –from February to April), this was the time of Marangani the crow.

The starting of a bush fire was a major element in the Waiyungari mythology and another possible reference to seasonal changes. In southern South Australia, fire was important to Aboriginal people as a tool in 'fire-stick farming', which took care of their country and produced new plant growth for the animals they hunted (Clarke 1988: 73, 74).[18] The Berndts (1993: 230) state that Waiyungari:

> was responsible for all natural growth. This theme was latent in all Kukabrak living and thinking at the level of the group as a whole.

The combined activities of Waiyungari and the two wives of Nepeli refer to seasonal changes, which also caused increased sexual activity between men and women. For instance, *narambi* initiates were said to be dangerously attractive to young women (Berndt & Berndt 1993: 178). During spring, sorcery activity was suspended as it was considered too dangerous then and perhaps, as the Berndts (1993: 261, 262) suggest, there was a prohibition 'to honour the season sponsored by the mythic Waiyungari'.

Waiyungari was considered a great hunter, with kangaroo skins often mentioned in the myth versions, and he was also associated with fishing. Wallaby carcases were sometimes thrown into a fire as a ritual offering to Waiyungari before a large hunting expedition (Taplin Journals, 23 September 1859; Berndt & Berndt 1993: 76). Taplin (1874 [1879: 57]) states that although Waiyungari was perceived as being in heaven, he 'is said to sit up there and fish for men with a fishing-spear, and when people start in their sleep it is thought to be because he touches them with the point of his weapon.' His prowess with the spear is also a feature of the mythology. Nevertheless, the act of throwing a spear into the Skyworld and the use of this as a form of ladder to climb up from the terrestrial landscape is not unique in Australian mythology. For example, there is a recorded belief from the Adelaide Plains people of how the Monana (ancestral beings)[19] climbed into the sky. Wyatt (1879: 16) states that his Adelaide Aboriginal source, Konoocha, claimed that 'Monana':

> was one day throwing large spears in various directions, east, west, north, south; when, having thrown one upwards, it did not return to earth. He then threw another, and another, and so continued throwing; each spear sticking fast to the former one until they reached the ground, and he climbed up by them to the sky, where he has ever since remained.[20]

Tindale (1935: 266) uses the similarity of Wyatt's account with that of Waiyungari to state that the 'Kaurna or Adelaide tribe' knew Waiyungari as 'Monana'. Nonetheless, without further connections between Waiyungari and the Monana, this conclusion appears tenuous in light of the wider distribution of some mythological themes.

The bridging of the gap between the Skyworld and the terrestrial landscape was variously recorded as achieved by the length of one or several spears, or on other occasions with the aid of a line attached. In two accounts the spear caused the Skyworld to fall down. In the case of the line attached to the end of the spear, this may relate to the use of 'magic rope' or 'hair cord' reported as used by Aboriginal doctors and sorcerers across Australia (Elkin 1977: 53, 54; Berndt & Berndt 1993: 262). It was believed that certain people could make this rope travel to the Skyworld, up trees, or through space itself. From the above accounts of the mythology, both Nepeli and Waiyungari had special powers. Regardless of the stated method employed by Waiyungari to escape the lower landscape, all these accounts

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[18] In the Lower Murray region during the 1850s, some colonists offered Aboriginal people incentives in the form of goods, if they could get through the dry season without starting a serious bushfire (Aboriginal Protectors Report of 1850, *South Australian Gazette & Colonial Record*, 20 April 1850, p.4.)

[19] Teichelmann & Schurmann (1840(2): 25) list 'Munana' as 'former; late; ancient' and 'Munaintyerlo' as 'of a very remote time; ancient'.

[20] The throwing of spears in various directions into the Skyworld is structurally similar to a myth from the Mid North of South Australia concerning the throwing of boomerangs in different directions to return the Sun from the Skyworld (Tindale 1937).

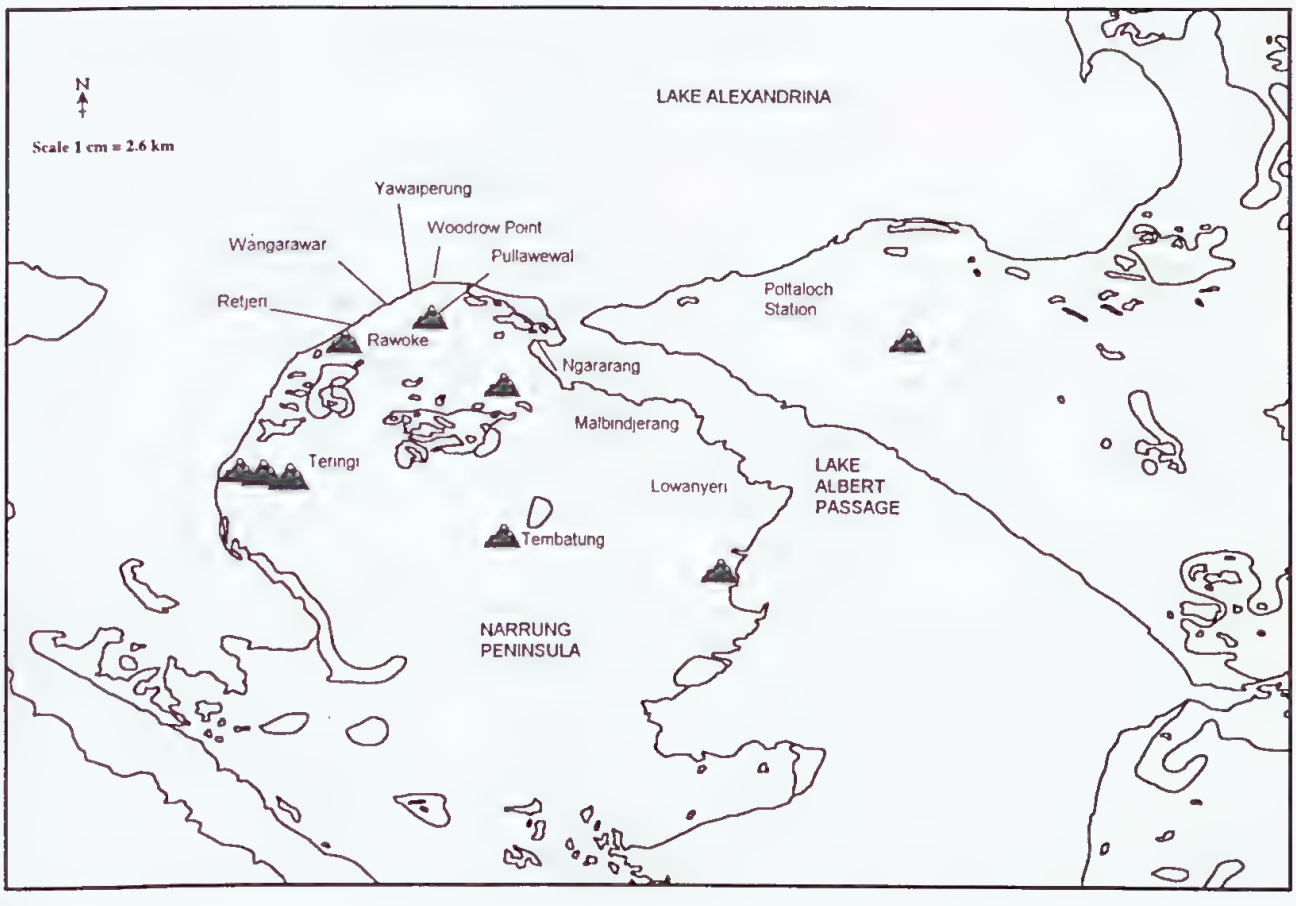

FIGURE 2. Places relating to the Waiyungari mythology in the Narrung Peninsula area (after Tindale 1935).

emphasise the great power of the ancestors in bridging the gap between land and sky. To ancestors, such as Waiyungari and Nepeli, the crossing of this boundary was achievable at high places like Rauwoke and Mulgarap-ngawan.

Tindale's Yaraldi informant, Frank Blackmoor, used the account of Waiyungari to explain the Aboriginal perception of the origin of fires on the Narrung Peninsula. In this manner, landscape-transforming events, such as bushfires, were given a human dimension. Tindale considered that the geographical context in his recorded Yaraldi version is a determinant of the cultural relevance of the Waiyungari story. For instance, due to the configuration of the Narrung Peninsula, bushfires in this region formerly had a tendency to sweep down the path along which Waiyungari fled, particularly in the face of summer north-westerly winds. The sites in the chase sequence of mythological events progressed to the south-east: from Wangaroka, to Malbindjerang and on to Mulgarap-ngawan (Fig.2). This track is entirely contained within the Lower Murray region, unlike that of Ngurunderi that passes right through. The Raminyerar version of the Waiyungari myth may also have had this directional theme, although terminating in the sea rather than the lakes. It is significant that the account of the myth obtained by Tindale from Clarence Long was predominantly located in the Narrung Peninsula landscape, even though this area was not directly relevant to Tangani-speaking people. The Waiyungari myth does not appear to relate directly to areas of the Coorong. The landscape is a crucial aspect of the mythology. As Tindale (1935: 273–274) stated:

> Lifted from this setting they [the myths] lose a great deal of their significance ... the legends, when associated with their geographical context, enable us to understand the people in a manner denied to those who know only the anglicised, generalised stories.

Through myths such as that of Waiyungari, not only the origins of the landscape are 'explained' but so too are such associated physical phenomena as bushfires. Nevertheless, apart from the bushfires, the seasonal and fertility aspects of the Waiyungari mythology are not stressed in Tindale's recording.

Many of the ethnographic accounts discussed in this paper involve Waiyungari's sacred status as an initiate, visibly indicated by his red

colouring. His association with young women was discouraged, although he had contact with older women, such as his mother. Young men during initiations were *narambi*, both taboo and sacred (see Berndt & Berndt 1993, chapter 10). Nevertheless, the main restriction in Lower Murray people divulging their acquired knowledge appears to have been by age. The Berndts state that for the young men, 'what they were told at this time, although sacred, was not secret; nor was it information that should be kept from women, because they already knew about these things' (Berndt & Berndt 1993: 163). The four myth cycles focussed upon during the initiations were of Ngurunderi, Marangani (Crow [= Raven]), the Young Men and Girls stars, and of Waiyungari and the two wives of Nepeli with whom he fled. The last cycle was apparently of particular importance to male initiations, the men being symbolic of Waiyungari and the women, whom they were to avoid, of Nepeli's wives. The events associated with Waiyungari are therefore of particular relevance to the prohibitions relating to young men. The initiations were usually commenced in September, when Waiyungari (as Mars?), was still present in the sky (Berndt & Berndt 1993: 169, 178). The themes of ancestors chasing wives and the temptation of initiates by young women are also to be found outside the Lower Murray region.[21] Nevertheless, local interpretations of particular myths were formulated according to specific landscapes.

Myths concerning Waiyungari are heavily interwoven with those of both Nepeli and Ngurunderi. There is a bias towards Ngurunderi in much of the literature. For example, Taplin (1879: 38) states:

> The great god of the Narrinyeri is Nurunderi [Ngurunderi]. They also believe in several demi-gods called Waiungare, Nepelle, and demons Pepi [Prupi?], Melapi [Mu:ldapi?], Nalkaru, Mulgewanke, and Karungpe.

This may, in part, be a reflection of the recorder's greater interest in landscape-creating ancestors, than those associated with seasonal behaviour. The mythological accounts of Waiyungari, Ngurunderi and Nepeli are linked to the extent that it is not possible to entirely separate them. For example, in the Waiyungari mythology there is some variation in the identity of the angry man who made the fires. It is sometimes a man named Pungngane or Nepeli and in one case it is Ngurunderi. In the latter case, it is likely that this is the result of a mistake by the publisher.[22] Waiyungari and Nepeli were generally considered to be brothers, although one source had the former as the nephew of the latter. In the case of Ngurunderi, he was often said to be Nepeli's brother in-law, although it is not stated whether he has the same relationship with Waiyungari. The kinship links also fan out to the north east of the Lower Murray towards the Darling River (see Berndt 1974: 25–27; Clarke 1995: 150). For instance, Ngurunderi's wives are also said to be the Bakindji sisters originally married to Tulu, who was the Kingfisher spirit killed in the Eaglehawk and Crow myth. Nepeli was also said to be the same being as the Nureli 'All-Father' spirit ancestor from further upriver. Rather than a high level of consistency in the mythology across the Lower Murray region, the roles of the ancestors were often interchangeable. Their actions were sometimes complementary, and at other times apparently antagonistic. For these reasons, they are best treated together as a myth complex, rather than as individual accounts of the landscape. The Berndts propose that whilst Ngurunderi's influence upon the Lower Murray people was perceived by them as mainly spiritual, that of Waiyungari was chiefly physical, with his sexual activity increasing the fertility of all natural species.[23]

Waiyungari Myths As European 'Stories'

Aboriginal myths have often been used as a

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[21] For instance, the Pulyallana mythology of Eyre Peninsula involves the ancestor chasing two wives across the landscape whilst creating landforms (see Clarke 1997: 128). There is also a version of the Ngurunderi myth, of dubious origin, that has his two wives attempting to elope with another unnamed ancestor (Bonwick 1870: 204). The chasing of two women occurs in the eagle and crow myths of the Maraura people, Lower Darling River, New South Wales (Tindale 1939). White (1975: 131,132) lists similar examples to Waiyungari of temptation in myths from across Australia.

[22] From a comparison between Hacket's own account (*Narrung Alpha*, August 1915 – personal collection of L. Padman) with that cited from him by Laurie (1917) there is clearly a discrepancy. In the first account (written by Hacket), the maker of the fire is nameless, being referred to as 'mighty man'. In the second (written by Laurie who cites Hacket), 'Nurundie' fills this apparent gap. Clarke (1995: 157, end note 14) noted this apparent error.

[23] In particular see Berndt & Berndt (1993, pp.75,287). The sexual influence of the Marangani constellation was also perceived as important, but relates more to the autumn season (see Clarke 1997: 137).

source of plots for stories written for a non-Aboriginal audience. One scholarly reader noted that Waiyungari appeared to be an Australian 'natives' version of 'Jack and the Beanstalk', presumably referring to the climbing into the Skyworld episode.[24] Some versions of Waiyungari written for wide readership, such as those by C. P. Mountford (1971: 36–37) and J. Isaacs (1980: 154–155), closely follow the outline of the detailed ethnographic account provided by Tindale (1935). Nevertheless, the geographical and seasonal aspects have been reduced. Stories written by other authors, who are discussed further in this section, appear to contain new elements that significantly alter the structure of the mythology.

In the Lower Murray mythology described by W. Ramsay Smith (1930: 183, 331), there is the 'Great Spirit' and lesser beings such as Ngurunderi, Nepeli and Waiyungari.[25] Smith (1930: 249–251) gives an account of Waiyungari in a section titled 'The Love-story of the Two Sisters'. As a child, Waiyungari was a gift from Ngurunderi to a childless widow who was mourning the death of her husband. Waiyungari was to become a 'deity', so great care was taken in his training and he could therefore not be given women in marriage. During one spring, the Mar-Rallang[26] sisters 'caught the spirit of the season' and became known to Waiyungari through them imitating the cry of the emu and then the 'love-note' of the swan. When he married the sisters, his 'uncle', who is not named, was angered and asked Nepeli to punish Waiyungari. A fire was made to separate Waiyungari and his two wives, and they fled into the lake. Waiyungari appealed to Nepeli for help, and then threw a spear with a bulrush fibre cord attached to it into Heaven. Nepeli caught the spear, thus allowing Waiyungari and the Mar-Rallang sisters to escape into the sky and become three stars.

The collection of Australian myths told as children's stories by E. Wilson contains 'The Story of Wyungare' (1950: 77–84). This version has Waiyungari as the son of Ngeringa, a woman of the 'Tilmuri' or musk duck 'totem'. Waiyungari was a gift from Ngurunderi to Ngeringa, who found the baby in the branches of a *Casuarina* tree.[27] It was said that Waiyungari would become a great warrior, but would one day return to the 'Sky-Land'. His name was said to mean 'One-Who-Returns-To-Sky-Land'. Ngeringa and her son lived with other 'Narrinyeri' (Ngarrindjeri) people on the shore of a 'big, shallow sea-lake', which was presumably Lake Alexandrina. Waiyungari became a renowned hunter and was permitted to visit the men's only 'bora-ground', where the voice of 'Kunapipi, the Roaring Devil-Devil' was heard. Due to his importance, he was given a hut and tract of hunting land to himself alone. Waiyungari was not allowed to marry. There were two young sisters, called 'Mar-Rallang' which reportedly meant 'Two-In-One', who lived on a neighbouring piece of land. They went to Waiyungari and became his wives. Wewat-Thelari, who was the 'chief' of Waiyungari's group, changed into a hawk and flew to the Sky-Land to consult Ngurunderi over the indiscretion. It was decided that the women must be driven away. This was attempted by starting a large bushfire, which drove Waiyungari and his two wives out onto a point in the lake. Due to the heat, they were forced into the water. Waiyungari appealed to Ngurunderi for help. He threw a spear with a 'magic rope' attached a long way into the sky. Ngurunderi caught the spear in his hands, and pulled up the wives and then Waiyungari. They were all allowed to live in the Sky-Land and 'shine forever'.

In A. W. Reed's (1980: 60–63) account, titled 'The Husband and Wives Who Became Stars', Waiyungari was a gift to a grieving childless widow from the 'ruler of the heavens'. In this

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[24] Letter from Charles Chewings to N.B. Tindale, dated 2 November 1935 (Chewings collection, AA59/1/1, Anthropology Archives, S.A. Museum).

[25] There is some evidence to suggest that the bulk of the mythology appearing in Ramsay Smith's volume was collected by a Ngarrindjeri man, David Unaipon (see Jones 1990: 303–305; Clarke 1997: 142, endnote 4). P. Jones (pers. com.) suggests that Ramsay Smith tampered with the cultural information in Unaipon's account, when producing the published version, thereby reducing its reliability as an ethnographic source.

[26] The name Mar-Rallang appears to be derived from *marrari* – 'sister', and *-engk-* 'they two' (Meyer 1843(2): 59,78). Related forms, Meralang and Maralangk, were names used for the Pages Islands as sites in the Ngurunderi mythology, which were reported to mean the 'Two Sisters' (Berndt 1940: 181; Berndt & Berndt 1993: 226).

[27] The choice of a Casuarina or sheoak tree may not have been accidental. The Casuarina tree has significance elsewhere in Lower Murray mythology, being the tree that Ngurunderi sat under before going into the Skyworld (Berndt 1940: 182). The large size of some trees allowed them to be perceived as a link between the Skyworld and terrestrial landscape (see Clarke 1997: 127,128).

version, the 'ruler' was Nepeli and his servant was Ngurunderi. As a young man, Waiyungari was initiated. He met the Mar-rallang (Mar-Rallang) sisters who called to him separately: one of whom was imitating the cry of an emu, the other the mating call of a swan. Waiyungari married them both. Nepeli considered this to be a illicit union between 'spirits of heaven' with 'daughters of the earth'. Ngurunderi was commanded to separate Waiyungari and the sisters, which was done by fire that pursued them into a shallow swamp. When the surrounding rushes began to burn, Waiyungari had the women climb onto his spear which he threw into the sky 'like a star that had mistaken its direction and was fleeing from earth', leaving himself behind. Due to his heroic act, Nepeli took pity on him and his spirit was lifted to join the two wives in living in the heavens, as three stars.

The popular accounts mentioned above are of mixed value as ethnographic sources of Aboriginal mythology. Some elements in Ramsay Smith's version relate closely to accounts of the mythology produced by anthropologists, although there are points where it differs significantly. For instance, the seasonal aspect of the story is important. Ramsay Smith (1930: 250) stated:

> The spring-time of the year is a great time in the training of the young people of the tribe. They are taught to become quick and observant in detecting the different love-notes of the wooing birds, and the mating impulses of the animals.

The impact of this time of the year on all people and creatures is a strong feature of this account. Nevertheless, there is no mention here of the *narambi* status of young men in providing a reason why the relationship between Waiyungari and the sisters was prohibited. The absence of ochre leads to the final destination of Waiyungari in the heavens as simply as a star, and not Mars (a red planet).

In the case of the Wilson account, the elements introduced have been appropriated from Aboriginal cultures elsewhere in Australia. The use of 'bora-ground' and Kunapipi are obvious inclusions from New South Wales and Arnhem Land respectively.[28] The use of Tilmuri ('Musk Duck'), Tinneware ('Bream'), and Ponde ('the Big Cod') are consistent with a Lower Murray origin of this account.[29] Other words, such as Milla-Milla ('child'), Bulwarra ('Pelican'), Dondu ('Black Swan'), Towrie (land), gunyah (shelter, hut), Ngurrung-Ngura ('the Red Sunset'), Gur-Gur ('Hawk'), and the phrase 'Hala-hala mai, oknira bata' ('Come here, great Teacher; here you and your wives shall live and shine forever!'), are not.[30] The gift of a baby to a childless woman by Ngurunderi, who appears to be a high god, has some resemblance to Christian beliefs concerning the birth of Jesus. In this respect, there appears to be some similarity with the Moriarty account published by Taplin. The uncertainty over the sources of Aboriginal ethnographic data and the lack of place names in such accounts militates against their use in describing local Aboriginal cultural landscapes.

There is a similarity in story structure and word usage between the accounts of Reed and Ramsay Smith (1930). Nonetheless, the roles of the three main characters in Reed's version is somewhat distorted from the main ethnographic accounts and popular accounts given above, with Nepeli given primacy over a subordinate Ngurunderi. The method of the women gaining access to the Skyworld is also different, involving one spear rather than many or, as with Ramsay Smith, with one spear and a cord. In Reed's account, the stated principal that prevented the marriage between Waiyungari and the sisters was the prohibition between the union between beings of different landscapes. The apparent replacement of the reason being initiate prohibitions with that of a type of taboo prohibiting unions between gods and mortals suggests that the author introduced this element, perhaps borrowed from classical Greek and Roman mythology. The impetus for changing the basic story may have come from the author's desire to create some original work.

The Waiyungari myth has had an impact upon the local place-names around Point McLeay. Pulawelwal Hill is a large mound situated between the Narrung township (near Point McLeay) and the Mann Cemetery on the road to Mark Point. The hill was sign-posted in the late

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[28] See Berndt (1970, 1974).

[29] Taplin (1879: 40,130) lists all these terms.

[30] These are either words derived by the writer or terms obtained from Aboriginal languages in eastern and northern Australia.

FIGURE 3. A Point McLeay resident, Susan Rankine, at 'Pulluwewal', 'Wyungare's Hill' (Photo: P.A. Clarke, 1990).

1980s by Narrung farmers as 'Pulluwewal', 'Wyungare's hill' (Fig.3).[31] Apparently, earlier this century a local farmer whose paddock covered most of the hill was in the habit of calling all his cows with names starting with 'Pulluwewal', for example 'Pulluwewal Daisy', 'Pulluwewal Mary' etc (L. Padman, pers. com.). The reinstating of the Aboriginal name for the hill therefore commemorates both Aboriginal and non-Aboriginal traditions. Wangarawar, the place in the myth where the wives first saw Waiyungari, is a point jutting into Lake Alexandrina on the north side of the Point McLeay township. This name is still used by Aboriginal residents and it appears on published local maps. Raukkan (a version of Rauwoke) is the local name for the area of the Point McLeay settlement, which is on the side of the hill where in mythology Nepeli lived. This has been used consistently by Aboriginal people since European settlement.[32] Several years ago this Aboriginal place-name officially replaced Point McLeay as the town name.

For eleven years, between 1988 and 1999, the major Aboriginal cultural exhibition at the South Australian Museum was 'Ngurunderi: a Ngarrindjeri Dreaming'. This took the theme of the Ngurunderi mythology and used it as a display device to describe the Ngarrindjeri culture of the Lower Murray region. The exhibition and the associated film have been a significant influence on public attitudes towards Aboriginal cultures in south-eastern Australia. The impact of these upon primary and secondary school curricula and university Aboriginal studies has also been significant.[33] This exhibition has been a successful exercise, judged in terms of giving the broader population an appreciation of the cultural complexity of a particular Aboriginal group. Nevertheless, although the ethnographic literature clearly gives Ngurunderi primacy, the result of this bias in the perceptions of people in more recent times is to underplay or ignore altogether the important roles of other beings, such as Waiyungari, in Lower Murray mythology.

Conclusion

In Lower Murray cosmology the spirit ancestor, Waiyungari, was important at the onset of spring to help bring about the change of seasons. Aboriginal people perceived that the fertility of their region relied upon this ancestor and the

[31] This placename has been listed by a number of recorders: Pulluwewal – 'at the house'; a spot near Point McLeay and said to be 'Waiungare's house' (Taplin 1874 [1879: 55,56,130]); Pulluwewal – isthmus between Lake Alexandrina and Lake Albert (Ramsay Smith 1930: 249); Pul:uwewal – camp of the spirit ancestor Waijungari (Tindale site recording map, Anthropology Archives, S.A Museum); Puleweiwald – Waiyungari's camp (Berndt & Berndt 1993: 191,228,317,400,442,443).

[32] There are number of variations of the placename, Raukkan. These include Rauukki, Rauwoke – 'the ancient way'; Point McLeay (Taplin 1874 [1879: 56,57,130,139,140]); Rewuk – Point McLeay (Yallop & Grimwade 1975, map and p.100); Rawukung – Point McLeay, site of the mission and primary living area of the Retjerindjeri clans people before mission established (Tindale site recording map, Anthropology Archives, S.A Museum); Rawukung – Raukkan (Berndt & Berndt 1993).

[33] For the exhibition booklet see Hemming & Jones (1989). Hemming (1988) describes the making of the film. Clarke (1995) discusses aspects the changing role of the Ngurunderi mythology. Examples of school use are seen in Education Department of South Australia (1990, 1991).

forces associated with him. His appearance in the sky was a marker of the arrival of the breeding seasons of animals and the beginning of the growth period for many plants. Firing the landscape was an important part of this regeneration. Waiyungari's influence was not restricted to animals and plants, but was important to people as well. Initiates were symbolically linked to the Waiyungari mythology. The ethnographic accounts of Waiyungari demonstrate the same range of variation in detail as previously discussed for other south-eastern Australian myths. The Waiyungari mythology appears to be chiefly relevant to the area bounded by Narrung Peninsula and Lake Albert Passage in terms of sites, and is therefore not of the same order in landscape modifications as, for instance, with Ngurunderi. Nevertheless, there are linkages with Waiyungari to the mythologies of Ngurunderi and other major spirit ancestors to the north east. The use of Waiyungari in popular writings has largely stripped out the important mythological elements that explained local Aboriginal perceptions of their land. This component of the literature is unreliable as an ethnographic source, and is best treated as fiction written for a non-Aboriginal readership with a partial relationship to Aboriginal cultural landscapes. Nevertheless, Aboriginal mythology is important to a much wider audience, forming a basis to investigate the Indigenous background of Australian culture. As the present cultural contexts for this mythology change, Waiyungari may yet re-emerge as an important vehicle for discovering the Aboriginal cultural landscape.

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References

AMERY, R. 1988. Sally and Harry: insights into early Kaurna contact history. Pp.49–87 *in* J. Simpson and L. Hercus (eds) 'History on Portraits. Biographies of nineteenth century South Australian Aboriginal people.' *Aboriginal History Monograph* 6. Australian National University, Canberra.

ANGAS, G. F. 1847a. 'Savage Life and Scenes in Australia.' Smith, Elder & Co., London.

ANGAS, G. F. 1847b. 'South Australia Illustrated.' T. McLean, London.

BELLCHAMBERS, J. P. 1931. 'A Nature-Lovers Notebook.' Nature Lovers League, Adelaide.

BERNDT, R. M. 1940. Some aspects of Jaraldi culture, South Australia. *Oceania*, **11**(2): 164–185.

BERNDT, R. M. 1959. The concept of 'the Tribe' in the Western Desert of Australia. *Oceania*, **30**(2): 82–107.

BERNDT, R. M. 1970. 'The Sacred Site: The Western Arnhem Land Example.' Australian Aboriginal Studies No.29. Australian Institute of Aboriginal Studies, Canberra.

BERNDT, R. M. 1974. 'Australian Aboriginal Religion.' Fascicle One – Introduction; the South-eastern Region. E. J. Brill, Leiden.

BERNDT, R. M. 1989. Aboriginal fieldwork in South Australia in the 1940s and implications for the present. *Records of the South Australian Museum*, **23**(1): 59–68.

BERNDT, R. M. and C. H. 1981. 'The World of the First Australians.' Revised edition. Lansdowne Press, Sydney.

BERNDT, R. M. and C. H. 1989. 'The Speaking Land.' Penguin, Melbourne.

BERNDT, R. M. and C. H., with STANTON, J. E. 1993. 'A World That Was. The Yaraldi of the Murray River and the Lakes, South Australia.' Melbourne University Press at the Miegunyah Press, Melbourne.

BLOWS, M. 1975. Eaglehawk and crow: birds, myths and moieties in south-east Australia. Pp.24–45 *in* L.R. Hiatt (ed.) 'Australian Aboriginal Mythology.' Australian Institute of Aboriginal Studies, Canberra.

BONWICK, J. 1870. 'Daily Life and Origin of the Tasmanians.' Sampson Low, Son, & Marston, London.

BOS, R. 1988. The Dreaming and social change in Arnhem Land. Pp.423–437 *in* T. Swain and D. Bird Rose (eds) 'Aboriginal Australians and Christian Missions. Ethnographic and Historical Studies.' Australian Association for the Study of Religions, Adelaide.

BROWN, A. R. (RADCLIFFE-BROWN) 1918. Notes on the social organisation of Australian tribes. *Journal of the Anthropology Institute, Great Britain*, **48**: 222–253.

CAWTHORNE, W. A. 1844. 'Rough Notes on the Manners and Customs of the Natives.' Manuscript held in the Public Library of South Australia, Adelaide. Edited version published 1926 in the *Proceedings of the Royal Geographical Society of Australasia, South Australian Branch*, **27**:44–77.

CHARLESWORTH, M. 1984. Change in Aboriginal religion. Pp.383–387 *in* M. Charlesworth, H.

Morphy, D. Bell and K. Maddock (eds) 'Religion in Aboriginal Australia. An Anthology.' University of Queensland Press, St Lucia.

CLARKE, P. A. 1986. The study of ethnobotany in southern South Australia. *Australian Aboriginal Studies*, number 2: 40–47.

CLARKE, P. A. 1988. Aboriginal use of subterranean plant parts in southern South Australia. *Records of the South Australian Museum*, **22**(1): 63–76.

CLARKE, P. A. 1991a. Adelaide as an Aboriginal Landscape. *Aboriginal History*, **15**(1): 54–72.

CLARKE, P. A. 1991b. Penney as ethnographer. *Journal of the Anthropological Society of South Australia*, **29**(1): 88–107.

CLARKE, P. A. 1994. 'Contact, Conflict and Regeneration. Aboriginal Cultural Geography of the Lower Murray, South Australia.' Ph.D. thesis. University of Adelaide, Adelaide.

CLARKE, P. A. 1995. Myth as history: the Ngurunderi mythology of the Lower Murray, South Australia. *Records of the South Australian Museum*. **28**(2): 143–157.

CLARKE, P. A. 1996. Early European interaction with Aboriginal hunters and gatherers on Kangaroo Island, South Australia. *Aboriginal History*. **20**: 51–81.

CLARKE, P. A. 1997. The Aboriginal cosmic landscape of southern South Australia. *Records of the South Australian Museum*. **29**(2): 125–145.

CLARKE, P. A. 1998. The Aboriginal presence on Kangaroo Island, South Australia. Pp.14–48 *in* J. Simpson and L. Hercus (eds) 'History on Portraits. Biographies of nineteenth century South Australian Aboriginal people.' *Aboriginal History Monograph* 6. Australian National University, Canberra.

CLARKE, P. A. 1999. Spirit Beings of the Lower Murray, South Australia. *Records of the South Australian Museum*. **31**(2): 149–163.

DARWIN, C. 1890. 'The Expression of the Emotions in Man and Animals.' Second edition. John Murray, London.

DAWSON, J. 1881. 'Australian Aborigines.' Robertson, Melbourne.

DURKHEIM, E. 1915. 'The Elementary Forms of the Religious Life.' Translated from the French by J. W. Swain. Allen & Unwin, London.

EDUCATION DEPARTMENT OF SOUTH AUSTRALIA. 1990. 'The Ngarrindjeri People: Aboriginal People of the River Murray, Lakes and Coorong.' Aboriginal Studies 8–12. Education Department of South Australia, Adelaide.

EDUCATION DEPARTMENT OF SOUTH AUSTRALIA. 1991. 'The Kai Kai Nature Trail: A Resource Guide for Aboriginal Studies.' Aboriginal Studies R–12. Education Department of South Australia, Adelaide.

ELIADE, M. 1958. 'Patterns in Comparative Religion'. Sheed & Ward, London.

EYRE, E. J. 1845. 'Journals of Expeditions of Discovery.' 2 vols. Boone, London.

HARVEY, A. 1939. Field Notebook. Fry Collection, AA105, South Australian Museum Anthropology Archives, Adelaide.

HARVEY, A. 1943. A fishing legend of the Jaralde tribe of Lake Alexandrina, South Australia. *Mankind*, **3**(4): 108–112.

HEMMING, S. J. 1988. Ngurunderi: a Ngarrindjeri Dreaming. *Records of the South Australian Museum*, **22**(2): 191–193.

HEMMING, S. J. and JONES, P. G., with CLARKE, P. A. 1989. 'Ngurunderi: an Aboriginal Dreaming.' South Australian Museum, Adelaide.

HERCUS, L. 1989. The status of women's cultural knowledge. Aboriginal society in north-east South Australia. Pp.99–119 *in* P. Brock (ed.) 'Women Rites and Sites. Aboriginal Woman's Cultural Knowledge.' Allen & Unwin, Sydney.

HIATT, L. R. 1975. Introduction. Pp.1–23 *in* L. R. Hiatt (ed.) 'Australian Aboriginal Mythology. Essays in Honour of W. E. H. Stanner.' Australian Institute of Aboriginal Studies, Canberra.

HIATT, L. R. 1996. 'Arguments about Aborigines. Australia and the Evolution of Social Anthropology.' Cambridge University Press, Cambridge.

ISAACS, J. 1980. 'Australian Dreaming: 40,000 Years of Aboriginal History.' Lansdowne Press, Sydney.

JACOBS, J. M. 1989. 'Women talking up big'. Aboriginal women as cultural custodians, a South Australian example. Pp.76–98 *in* P. Brock (ed.) 'Women Rites and Sites. Aboriginal Woman's Cultural Knowledge.' Allen & Unwin, Sydney.

JENKIN, G. 1979. 'Conquest of the Ngarrindjeri: the Story of the Lower Lakes Tribes.' Rigby, Adelaide.

JONES, P. G. 1990. 'Unaipon, David' entry in J. Ritchie (ed.) 'Australian Dictionary of Biography.' **12**: 303–305. Melbourne University Press, Melbourne.

KOLIG, E. 1984 [1981]. The mobility of Aboriginal religion. Pp.391–416 *in* M. Charlesworth, H. Morphy, D. Bell, and K. Maddock (eds) 'Religion in Aboriginal Australia: an Anthology.' University of Queensland Press, St Lucia.

LAURIE, D. F. 1917. Native legend on the origin of Orion's belt. *Transactions and Proceedings of the Royal Society of South Australia*, **41**: 660–662.

McCOURT, T. and MINCHAM, H. (eds) 1977. 'Two Notable South Australians: Captain Emanuel Underwood 1806–1888 and Duncan Stewart 1834–1913.' Beachport Branch of the National Trust, Beachport.

McCOURT, T. and MINCHAM, H. 1987. 'The

Coorong and Lakes of the Lower Murray.' National Trust, Beachport.

MADDOCK, K. 1976. Communication and change in mythology. Pp.162–179 *in* N. Peterson (ed.) 'Tribes and Boundaries in Australia.' Social Anthropology Series No.10. Australian Institute of Aboriginal Studies, Canberra.

MATHEW, J. 1928. The religious cults of the Australian Aborigines. *Report of the Australian Association for the Advancement of Science*, **28**: 524–540.

MEYER, H. A. E. 1843. 'Vocabulary of the Language Spoken by the Aborigines of South Australia.' Allen, Adelaide.

MEYER, H. A. E. 1846. 'Manners and Customs of the Aborigines of the Encounter Bay Tribe, South Australia.' Reprinted pp.185–206 *in* J.D. Woods (ed.) 1879. 'The Native Tribes of South Australia.'. E. S. Wiggs & Sons, Adelaide.

MOORHOUSE, M. 1843. Annual Report of the Aborigines Department for the Year Ending 30th September 1843. Reprinted 1990 in *Journal of the Anthropological Society of South Australia*, **28**(1): 54–62.

MOORHOUSE, M. 1846. 'A vocabulary ... of the Murray River Language.' Reprinted in T.A. Parkhouse (ed.) 1935. 'The Autochthones of Australia.' Published by the editor, Adelaide.

MORTON, J. 1994. Review of 'A Place for Strangers: Towards a History of Australian Aboriginal Being' by T. Swain. *Oceania*, **65**(1): 94–95.

MOUNTFORD, C. P. and ROBERTS, A. 1969. 'The Dawn of Time.' Griffin Press, Adelaide.

MOUNTFORD, C. P. and ROBERTS, A. 1971. 'The First Sunrise.' Griffin Press, Adelaide.

MYERS, F. R. 1986. 'Pintupi Country, Pintupi Self.' Australian Institute of Aboriginal Studies, Canberra.

NEWLAND, S. 1889. Parkengees or aboriginal tribes on the Darling River. *Proceedings of the Royal Geographical Society of Australasia, South Australian Branch*, 20–32. Also booklet, pp.1–16.

PARKER, K. L. (STOW, C.) 1936. The legend of Naroong-owie, the sacred island. P.82 *in* 'A Book of South Australia: Women in the First Hundred Years.' Collected and edited by L. Brown et al. Rigby, Adelaide.

PENNEY, R. 1840–43. The spirit of the Murray. *South Australian Magazine*. Reprinted 1991 in *Journal of the Anthropological Society of South Australia*, **29**: 27–87.

RATZEL, F. 1896. 'The History of Mankind.' Translated from the second German edition by A. J. Butler. Macmillan, London.

REED, A. W. 1980. 'Aboriginal Stories of Australia.' Reed Books, Sydney.

ROHEIM, G. 1971. 'Australian Totemism. A Psychoanalytic Study in Anthropology.' Frank Cass & Co., London.

ROSE, D. BIRD 1988. Jesus and the dingo. Pp.361–375 *in* T. Swain and D. Bird Rose (eds) 'Aboriginal Australians and Christian Missions. Ethnographic and Historical Studies.' Australian Association for the Study of Religions, Adelaide.

SCHWAB, J. 1988. Ambiguity, style and kinship in Adelaide Aboriginal identity. Pp.77–95 *in* I Keen (ed.) 'Being Black. Aboriginal Cultures in "Settled" Australia.' Aboriginal Studies Press, Canberra.

SMITH, W. RAMSAY 1930. 'Myths and Legends of the Australian Aboriginals.' Harrap, Sydney.

STIRLING, E. C. 1911. Preliminary report on the discovery of native remains at Swanport, River Murray, with an enquiry into the alleged occurrence of a pandemic among the Australian Aborigines. *Transactions of the Royal Society of South Australia*, **35**: 4–46.

SUTTON, P. 1988. Myth as history, history as myth. Pp.251–268 *in* I Keen (ed.) 'Being Black. Aboriginal Cultures in "Settled" Australia.' Aboriginal Studies Press, Canberra.

SWAIN, T. 1993. 'A Place for Strangers. Towards a History of Australian Aboriginal Being.' Cambridge University Press, Cambridge.

TAPLIN, G. 1859–79. Journals. Mortlock Library, Adelaide.

TAPLIN, G. 1874 [1879]. The Narrinyeri. Pp.1–156 *in* J.D. Woods (ed.) 'The Native Tribes of South Australia.' E. S. Wiggs & Sons, Adelaide.

TAPLIN, G. 1879. 'Folklore, Manners, Customs and Languages of the South Australian Aborigines.' South Australian Government Printer, Adelaide.

TEICHELMANN, C. G. and SCHURMANN, C. W. 1840. 'Outlines of a Grammar ... of the Aboriginal Language of South Australia.' 2 pts. Thomas & Co., Adelaide.

THOMSON, D. F. 1939. The seasonal factor in human culture. *Prehistory Society Proceedings*, no. 5.

THOMSON, D. F. 1949. 'Economic Structure and the Ceremonial Exchange Cycle in Arnhem Land.' Macmillan, Melbourne.

TINDALE, N. B. 1930–52. 'Murray River Notes.' Anthropology Archives, South Australian Museum.

TINDALE, N. B. 1931–34. 'Journal of Researches in the South East of South Australia.' Vol.1. Anthropology Archives, South Australian Museum.

TINDALE, N. B. 1934–37. 'Journal of Researches in the South East of South Australia.' Vol.2. Anthropology Archives, South Australian Museum.

TINDALE, N. B. 1935. MS. 'Notes on the Kaurna or Adelaide Tribe and the Natives of Yorke Peninsula and the Middle North of South Australia.' Anthropology Archives, South Australian Museum.

TINDALE, N. B. 1935. Legend of Waijungari, Jaralde

tribe, Lake Alexandrina, South Australia, and the phonetic system employed in its transcription. *Records of the South Australian Museum*, 5(3): 261–274.

TINDALE, N. B. 1937. Two legends of the Ngadjuri tribe from the middle north of South Australia. *Transactions of the Royal Society of South Australia*, **61**: 149–153.

TINDALE, N. B. 1938. Prupe and Koromarange: a legend of the Tanganekald, Coorong, South Australia. *Transactions of the Royal Society of South Australia*, **62**: 18–23.

TINDALE, N. B. 1938–56. 'Journal of Researches in the South East of South Australia.' Vol.1. Anthropology Archives, South Australian Museum.

TINDALE, N. B. 1939. Eagle and crow myths of the Maraura tribe, Lower Darling River, New South Wales. *Records of the South Australian Museum*, **6**: 243–261.

TINDALE, N. B. 1974. 'Aboriginal Tribes of Australia: Their Terrain, Environmental Controls, Distribution, Limits, and Proper Names.' Australian National University Press, Canberra.

TINDALE, N. B. 1981. Desert Aborigines and the southern coastal peoples: some comparisons. Pp.1855–1884 *in* A. Keast (ed.) 'Ecological Biogeography of Australia.' Junk, The Hague.

TINDALE, N. B. 1987. The wanderings of Tjirbruki: a tale of the Kaurna people of Adelaide. *Records of the South Australian Museum*, **20**: 5–13.

TINDALE, N. B. and MOUNTFORD, C. P. 1936. Results of the excavation of Kongarati Cave near Second Valley, South Australia. *Records of the South Australian Museum*, 5(4): 487–502.

TINDALE, N.B. and PRETTY, G.L. 1980. The surviving record. Pp.43–52, 228 *in* R. Edwards and J. Stewart (eds) 'Preserving Indigenous Cultures: a New Role for Museums.' Australian Government, Canberra.

TURNER, D. H. 1980. 'Australian Aboriginal Social Organisation.' Humanities Press, Atlantic Highlands and Australian Institute of Aboriginal Studies, Canberra.

WHITE, I. M. 1975. Sexual conquest and submission in the myths of central Australia. Pp.123–142 *in* L. R. Hiatt (ed.) 'Australian Aboriginal Mythology. Essays in Honour of W. E. H. Stanner.' Australian Institute of Aboriginal Studies, Canberra.

WILSON, E. 1950. 'Churinga Tales. Stories of Alchuringa – The Dreamtime of the Australian Aborigines.' The Australasian Publishing Co., Sydney.

WYATT, W. 1879. Some account of ... the Adelaide and Encounter Bay tribes. Pp.157–181 *in* J.D. Woods (ed.) 'The Native Tribes of South Australia.' E. S. Wiggs & Sons, Adelaide.

THE PACIFIC CULTURES GALLERY* IN THE SOUTH AUSTRALIAN MUSEUM

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This paper recounts the history of the Pacific exhibits in the South Australian Museum, focussing after 1895 on those exhibits located on the top floor of the North Wing. This space has become known as the Pacific Cultures Gallery even though natural science exhibits have shared the space. Over the decades there has been a consistent evolution of the display until now, just over a century after the opening of the North Wing, the opportunity exists for the Gallery to be devoted solely to the display of Pacific cultural material.

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Pacific Foundations

From its foundation in 1856, the South Australian Museum has had a strong and continuing interest in the Pacific.

> It was in 1860 that the Museum secured as a donation from William Owen, M.P. a large series of articles from Fiji, including tapa cloth, clubs, spears and clothing, and also some Malayan models of pirate praus; thus, as far as can be ascertained, the Museum secured the first of its now extensive Pacific Island and Indonesian collections (Hale 1956: 12).

One of the first exhibits of this museum was a display of Fijian material.

> [William] Owen's collection of Fijian "curiosities", installed in a special "Fijeean room", was the centrepiece of the museum's ethnographic exhibits when it opened to the public for the first time [on 2 January 1862]. By the 1860s Australian Aborigines and their objects no longer retained their capacity to evoke the exotic from the inhabitants of Adelaide – this role was filled by Pacific artifacts, particularly those from Fiji. Owen's Fijian collection was complemented by New Caledonian objects . . . contributed by Robert Gouger[1] (Jones 1993: 21).

Elsewhere Jones (1996b: 28) informs us that 'Among the ethnographic objects it was the Fijian rather than the Aboriginal artefacts which evoked most critical and public interest' and Hale (1956: 13) noted that, 'the Fijian collections had been exhibited from time to time' even before the Museum opened in the South Australian Institute building in 1862.

The Institute building soon became overcrowded for its three functions as Museum, Library and Art Gallery and in 1878 a complex to the east of the existing building was planned. This was to consist of four multi-storied structures set around a courtyard (ibid., Plate oppos. p.35), only two of which have been built. The westernmost wing was commenced in November 1879 and was occupied progressively until its official opening in December 1884 as the Jervois (or West) Wing.[2] Each of the cultural institutions occupied about a third of the space in the new building. Dr Wilhelm Haacke was appointed as the first Director of 'The South Australian Museum' in February 1883 and began a vigorous program of expansion of the functions and collections of the Museum (ibid.: 39ff.).

Amandus Heinrich Christian Zietz (Fig. 1) was engaged as a preparator in 1884 and by 1888 had progressed to Assistant Director under Stirling who, as Chairman of the Museum Committee, was acting unofficially as the Director following

* **Note:** The Pacific Gallery is closed for renovations and will reopen in March/April 2000.

[1] Gouger's collection is not identifiable in the present collections; labels were lost from many objects before registration was formally commenced in 1911 and where objects could not be matched with various lists they were labelled 'Old Collection'.

[2] In 1884 the South Australian Institute became the Public Library, Museum and Art Gallery of South Australia. This arrangement was not changed until separation of each institution by Acts of State Parliament in 1939.

FIGURE 1. Amandus Heinrich Christian Zietz (from Hale 1956, oppos. p.41).

the departure of Haacke in 1884.[3] Zietz, born in Denmark, had previously been a preparator and then a curator at the Zoological Institute Museum at Kiel, interested mainly in birds and fishes, and became 'right hand man to Stirling for 25 years' (Hale 1956: 41). Edward Charles Stirling (Fig. 2) was appointed Honorary Director in 1889, confirming the role he had been playing unofficially.

As a result of Haacke's short but energetic Directorship, the Museum had quickly outgrown its accommodation. By 1883 the Museum's ethnological collection had been boosted by other Pacific material from New Guinea (ibid.: 42). Although in 1884 'ethnological material from Fiji and the southeast of New Guinea was in hand, but very little other Pacific Islands material' (ibid.: 46), by 1887 this ratio had changed in such a way that Zietz was able to state that 'the New Guinea collection now forms the most noteworthy part of the ethnological collection' (*Annual Report* of 1886–87: 19).

A detailed inventory by Zietz can be found in the *Annual Report* 1887–88: 18:

> Fiji represented by about 100 specimens; . . . Solomon Islands represented by about 23 specimens; New Britain Islands represented by about 80 specimens; . . . New Guinea Islands represented by about 300 specimens; Australia (including all the colonies) about 400 specimens, exclusive spears. . . . Nearly the whole of the Fijian collection was presented by W. Owen, Esq., and

FIGURE 2. Edward Charles Stirling (from Hale 1956, oppos. p.51).

[3] One of the reasons for Haacke's untimely departure was some dissatisfaction with his readiness to send specimens to other institutions abroad. Hale notes (1956: 47) that among these were 'Fijian collections said to have been sent to Germany (apparently most of the William Owen collection, donated in 1860)'. It is also of interest that after he left the Museum, Haacke joined the 'Bonito' expedition to Papua sponsored by the Royal Geographical Society of Australia, which spent June to December 1885 exploring the Strickland River, a tributary of the Fly. The ethnographic collections from this expedition were lodged in the Colonial (now State) museums in Brisbane, Sydney and Melbourne.

> contains many valuable specimens. New Guinea, represented by about 300 specimens, forms undoubtedly the most attractive and valuable part of the whole collection . . . Some sketches, showing native houses, villages, and scenery, are included in the collection, but photographs of the Papuans are still wanted.

Jones (1996b: 55–63) attributes the marked increase in South Australian interest in ethnographic material during the 1880s to the popularity of the International Exhibitions (especially South Australia's constribution to the Colonial and Indian Exhibition in London in 1886) and their counterparts in Sydney, Melbourne and Adelaide. Hale (1956: 64) especially remarks on the Jubilee Exhibition in Adelaide in 1887, for which a special building was erected on North Terrace and which featured 'a splendid collection of Malayan products, including a complete series of ethnological objects' provided by the Sultan of Johore, and 'good New Guinea ethnological material – the Theodore Bevan collections from "the Douglas and Jubilee Rivers"'; both collections were obtained for the Museum after the Exhibition closed.

> The Exhibitions elevated the notion of civilisation's progress by means of sophistication in technology. It was natural that the tools and weapons of 'savage' societies would be regarded in juxtaposition to this sophistication, providing a measure of progress for the throngs of visitors (Jones 1996b: 57).

The Museum's North Wing – 'a building provided solely for its purpose'

Stirling kept abreast of museum developments abroad and embraced the taxonomic classification system which treated ethnographic material in much the same way as natural history specimens. Thus he 'became aware of the potential for filling those gaps in collections which taxonomic systems made evident' (ibid.: 64). Ethnographic material was classified primarily on the basis of object type and presented by geographic regions to facilitate comparison. This motivated Stirling to seek out specimens from geographic areas not hitherto represented in the Museum's collections. To supplement the Australian Aboriginal ethnographic collections he issued a circular to police and telegraph officers during the mid-1890s appealing for material (ibid.: 196) and several Lutheran missionaries provided well-documented Aboriginal material around the turn of the century. Stirling also obtained several Pacific collections from Anglican, Presbyterean and Methodist missionaries based in Adelaide but these were usually poorly documented.

All this activity rapidly increased the size of the Museum's ethnographic collection and Stirling worked energetically to gain new space for the Museum. This was accomplished by the construction of a building where the north wing of the cultural institutions complex was meant to be located but there were insufficient funds to build in the style of the first structure (the Jervois Wing).[4] Meanwhile, in 1889, the Art Gallery was moved out of the Jervois Wing into the Jubilee Exhibition Building[5] further to the east on North Terrace.

In January 1895, the North Wing[6] was officially opened (Hale 1956: 69). This was a modest red-brick structure with a ground floor and an upper floor gained by an impressive staircase. Two large light wells in the upper floor allowed light from a glass roof to illuminate the ground floor (Fig. 3). This same year Stirling was appointed salaried Director, a position he retained until 1913.

Regarding the move of the collections when the building work had finished, Jones writes (1993: 27):

> [Stirling's] organization of the transfer of museum collections from the Jervois Wing to the new North Wing of the Museum in 1893 enabled him to further gauge the strengths and weaknesses of the Pacific collections.

Although Stirling undoubtedly provided overall direction of the operation, Hale (1956: 72–3) attributes much of the detailed work to Zietz:

> So rapid was the progress in occupying the two

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[4] Presently occupied by the Mortlock Library, a part of the State Library.

[5] Although arguments were put to government in 1882 to complete the building of the four wings of the cultural institutions as proposed in 1878, to house the Jubilee exhibitions of 1887 and then use these buildings for the Library, Museum and Art Gallery, this was not done (Hale 1956: 69). Instead the Jubilee Building was constructed and after the 1887 Exhibition was used for a number of purposes, finally being demolished in the 1960s to make way for a University of Adelaide underground car park.

[6] The North Wing is sometimes referred to as the West Wing in Reports and correspondence. Although it was the North Wing in the original 1878 plan it was thought of as the West Wing when the Museum's second (East) wing was built.

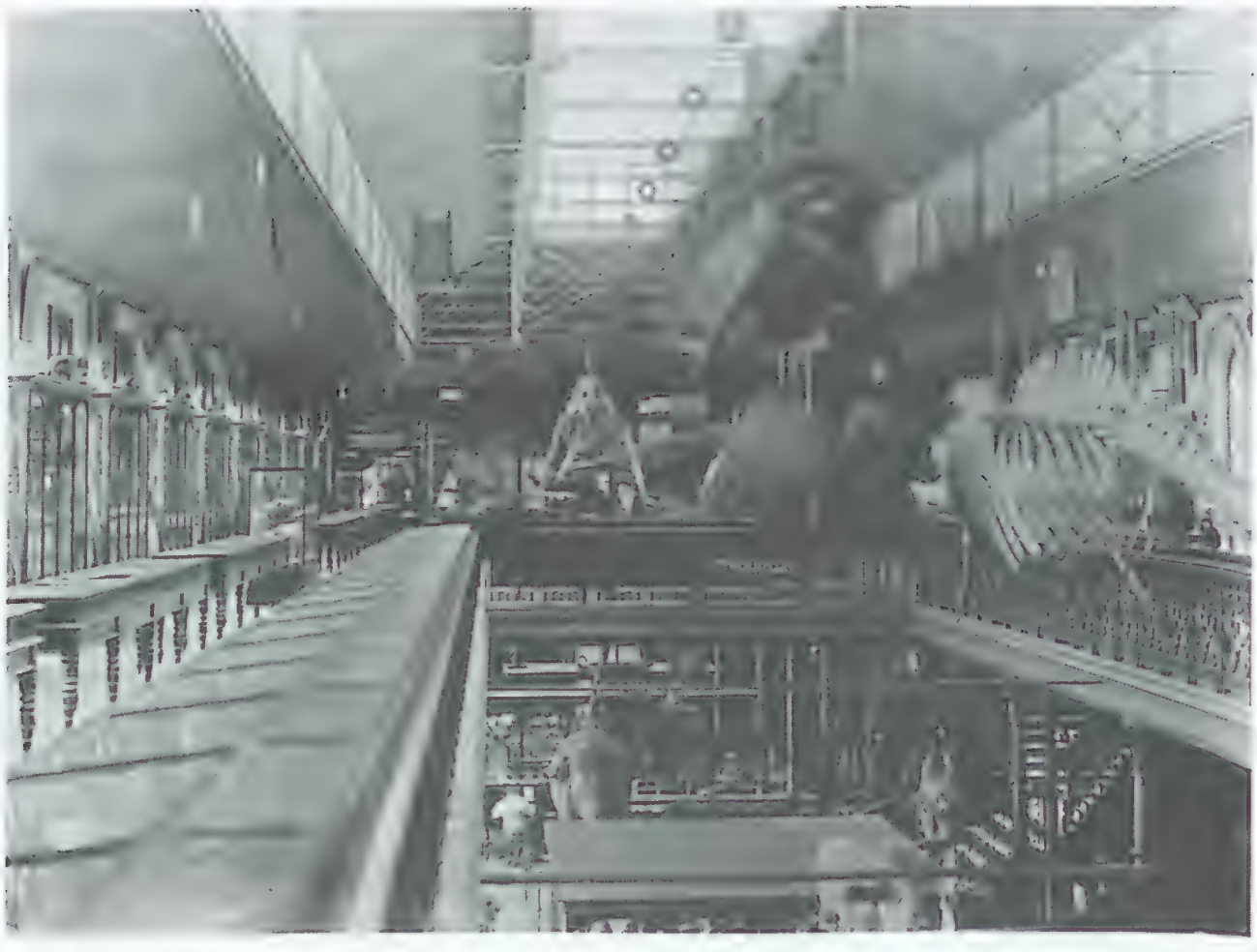

FIGURE 3. Photograph of top floor, West (ie. North) Wing, 31 November 1899 by Mr A. Treichel; view from eastern end of Gallery looking west; eastern lightwell in mid-ground and 'Bridge Case' in centre of Gallery. Note Fijian exhibit in south-western corner where it has remained to this day.

> floors of this building, 230 feet in length, and so pleasing was the arrangement to Stirling, that he enthusiastically reported to his committee that Zietz, 'on whom fell the chief labour of the removal and rearrangement of the collections has dealt with this tedious and arduous undertaking with an intelligent energy that deserves commendation'.

The Pacific Islands displays at that time were only a small part of the total exhibitions but they have expanded and evolved in that space ever since. Hale records (ibid.: 81):

> The Pacific Island ethnological material had so increased by 1898 that it occupied the whole of the wall cases on the southern side of the Museum. This was soon augmented by Fijian weapons and tools, 133 in all, presented by James Angas Johnson.[7]

However, the collection was far from being arranged in a pedagogically sensible way. Most exhibits lacked labels. As a result, visitors neither knew where exactly the specimens hailed from nor what they were in the first place: 'The ethnological cases are so congested that a systematic or scientific arrangement, or any descriptive labelling, is quite impossible' (Stirling in *Annual Report* 1902–03: 9).

Missing labels, though, were a shortcoming which could be set right with comparatively small financial means. Zietz, responsible for the ethnological department as Assistant Director from 1888–1909, wrote: 'The Fijian Collection has been temporarily re-arranged and printed labels attached to the specimens' (ibid.).

Thus it appears that the installation of the Pacific Cultures Gallery on the upper floor of the North Wing was largely the work of Zietz, presumably with some general direction from

[7] Johnson obtained the collection on behalf of the Museum from Mr D. Garner Jones of Levuka, Fiji, in 1900. The most valuable of these items is a headrest (*kali*), A.7313, which 'Belonged to Tanoa, King of Fiji'.

FIGURE 4. Edgar Ravenswood Waite (from Hale 1956, oppos. p.95).

Stirling. Amandus Zietz retired in December 1909 and his son, Robert, took up his father's duties in ornithology.[8]

At the end of 1912, after 32 years of working at various posts at the South Australian Museum, Stirling resigned from his position as Director but continued for a short time as Honorary Director. In 1914, Edgar Ravenswood Waite (Fig. 4) took over as Director (Hale 1956: 95–6); Stirling concentrated on the displays of Australian and Pacific ethnography 'and continued to exert strong influence within the institution as Honorary Curator of Ethnology until his death in 1919' (Jones 1993: 27). It was during this period that Stirling put his mark on the Pacific Gallery exhibits.

The famous anthropologist, Bronislaw Malinowski, who had extensive knowledge of the Melanesian region and especially of its trade relations, had a brief association with the Museum, Jones reports (1993: 27):

> Stirling was . . . [indirectly] responsible for the acquisition of at least one item attributable to the anthropologist Bronislaw Malinowski . . . This object, a 'woman's dress' (A.7703), was deposited in the Museum collection by Edward Stirling's daughter, Nina, to whom Malinowski had become briefly engaged during his stay in Adelaide at the Stirlings' Mt. Lofty home in 1914.

It is most likely that Malinowski visited the Pacific displays and made comments on them. However, it remains uncertain to what extent Stirling would have been influenced by these comments in the re-arrangement which was conducted only a few years later.

The Museum's East Wing – 'The Australian Court'

The possibility of a re-structuring arose in 1915 with the opening of the East Wing[9] (Fig. 5) of the museum, which became known as 'the Australian Court'.

> Exhibition space on the galleries was now almost trebled and for the first time in the history of the Museum it was possible, for a while, to segregate the Australian material from the extra-Australian or so-called 'general collections' (Hale 1956: 103).

It was this re-organisation of museum exhibits which made space for the expansion of the Pacific exhibits and their occupation, eventually, of all the wall cases on the upper level of the North Wing (ibid: 107).

Over-crowding of the cases was a problem alluded to repeatedly in Annual Reports. Because there was inadequate provision for storage of reserve collections, the safest course was to put as much as possible on display, where the condition of the objects could be monitored. The only other solution would have been to create more space in the galleries and it was not possible to consider increasing floor space by filling in the light-wells until illumination of cases by cheap electric lighting became feasible with the general availability of fluorescent tubes. Still, Stirling tried to make the most of the situation, to improve the displays and to make them ethnologically more sensible.

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[8] Several years later, Robert Zietz was also given the task of registering all the ethnological specimens on display, which took three years to accomplish (Hale 1956: 107) but there is no indication that he was involved in reorganising the Pacific displays.

[9] The East Wing was designed to match the style of the Jervois Wing which by then was completely occupied by the State Library. Thus half of the original 1878 plan was executed (Hale 1956: 97).

FIGURE 5. The East Wing of the South Australian Museum; North Wing to left.

In 1917, he re-arranged the material from Fiji yet again:

> Fiji – This series, containing some very valuable specimens collected in the old days, and now not procurable, which was before very overcrowded, has been rearranged to better advantage, but the cases are even now still rather congested (Stirling in *Annual Report* 1916–17: 13).

However, it was still impossible to structure the gallery systematically. All Stirling could really do was fill 'gaps' with newly acquired material which was kept safest in the display cases. It is hardly surprising that it was not always possible under these circumstances to integrate the specimens in a regionally or thematically correct way.

> On the days of writing I am engaged on the work of their arrangement [i.e. of some newly acquired specimens from New Guinea] and, though an interesting exhibit may be possible, it is evident that all the specimens cannot be placed on view. This is unfortunate, as they are interesting, attractive, and intrinsically good. In any case, owing the want of sufficient and suitable cases, a systematic arrangement cannot be strictly followed (ibid.).

It was another ten years after the East Wing was opened to the public in 1915 before all the Australian ethnological material was removed from the North Wing allowing more Pacific exhibits the use of the space.[10] In the Annual Report 1917–18: 10, Waite wrote:

> The gallery of this court [ie. the upper level of the North Wing] is devoted mainly to Ethnology; about half the space is occupied with the overflow from the Australian court, the remainder accommodating the Pacific Islands material, of which we possess a very unequal display. Advantage was taken of about 30 small hanging wall cases to house some of the more remarkable or beautiful objects of native manufacture.

The small hanging wall cases Waite mentioned,[11] as well as another re-arrangement,

[10] Upon completion of the East Wing, the available space had to be shared with some of the collections of the Art Gallery, curtailing the building's use for Museum purposes until the completion of the Art Gallery's Melrose Wing in 1937 (Stirling 1956: 147).

[11] These small 'hanging wall cases' may have been those located above the main wall cases along the north wall of the Gallery. These were criticised several years later by a visiting overseas museum professional as being too high for people to see their contents clearly.

were the last things Stirling was occupied with before his death in 1919:

> The time at my disposal during the past year has been almost exclusively devoted to the re-arrangement of the Papuan, Melanesian, and Polynesian collections in the gallery of the General Court. With the specimens from these localities formerly displayed there have now been incorporated the valuable and extensive series of stone clubs, ceremonial, and other articles from Papua presented by Major Balfour Ogilvy, which form a notable addition. Various other similar collections acquired by donation from other sources and by purchase have also been similarly incorporated. The result of these additions is that the collections from the regions mentioned have been very considerably augmented, both in number and value. About 2 200 specimens in this category have been catalogued and placed on exhibition. By the re-arrangement these objects, many of them of a striking character, are now shown more effectively and somewhat more methodically than was previously the case. It is, however, admitted that the cases are still undesirably overcrowded, and, owing to the stringent limitations of space, it has been found impossible to adhere strictly to a geographical classification, which would have been highly desirable. However, under existing conditions, nothing better could be done. The main advantage gained is, that the specimens in question, many of them of a fragile or perishable nature, can now be constantly kept under observation, so that we shall be free from the anxieties as to the fate of articles that are packed up and stored (ibid.).

No doubt a major impetus for the expansion of the Pacific exhibits in the post-World War One period was the collecting expedition by Edgar Waite to the Bismarck Archipelago of New Guinea for four months in 1918 (Craig 1995; Hale 1956: 115–116; Jones 1992), following Australia's military occupation of German New Guinea in 1914. 'Waite brought back with him collections which occupied six tons of shipping space' (Hale 1956: 115). These collections consisted of both natural history and ethnographic specimens.

The ethnographic material collected by Waite is today prominently represented in the Pacific Gallery, particularly in the New Ireland displays. Other collections from New Guinea were obtained from officers (e.g. Major H. L. S. Balfour Ogilvy) serving there with the Australian Military Expeditionary Force, some of whom (e.g. Captain A. J. Hunter) stayed on as District Officers when civil administration resumed after the conclusion of the War.

On 20 March 1919, Sir Edward Stirling died. He left a legacy of an amazing 10 000 Australian Aboriginal and Pacific ethnological specimens on exhibition (ibid.: 107). Temporarily, Director Waite took over the Department of Ethnology and had soon to admit:

> Your Director is . . . responsible for the care and conduct of the Ethnological collections formerly controlled by the late Sir Edward Stirling; it cannot be surprising, therefore, if he is unable to produce much evidence of scientific research (*Annual Report* 1920–1921: 9).

Despite his increased responsibilities, Waite launched a project in 1920 which indirectly led to the upper level of the North Wing being stocked exclusively with ethnological exhibits from the Pacific, although the mineral exhibits remained. In the *Annual Report* 1919–20: 10, Waite set out his plan:

> Of these needs the following are the principal . . . The complete fitting with cases of the annexe to the Stirling Gallery of Australian Ethnology. The space thus obtained would relieve the General Court [North Wing] of the Australian weapons there exhibited, and permit of much valuable material from the Pacific Islands being shown.

It is hard to date precisely, from the archival sources available, when the Pacific Gallery had expanded to the point where it 'occupied the wall cases on all sides of the upper floor' (Hale 1956: 107), but Hale comments upon it immediately after noting that 'the Australian ethnologia from the north wing was removed in 1924' (ibid.). Probably it took place progressively over the next year or so. Waite, in the *Annual Report* 1924–25: 11, stated:

> The space set free rendered it possible to re-arrange considerably the general collection, and to add many fine exhibits, including specimens obtained by the Director, in 1918, in New Guinea, New Britain, and especially New Ireland.

In 1928, Waite died on his way to a Science Congress in Hobart, Tasmania. Herbert Hale was appointed 'Museum Curator' after applying for the position of Director and three years later, in 1931, was appointed Director. Also in 1928, Norman Barnett Tindale (Fig. 6), the next person to have a significant impact on the Pacific Gallery, became the museum's ethnologist (Hale 1956: 138; Jones 1996a). He had started at the museum in 1918 in the entomological section (under a kind of apprenticeship rather than as an academic student) but within a few years had developed an interest in ethnology as well.

Tindale's first experience in collecting ethnographic material was in 1921–2 on Groote

FIGURE 6. Norman Barnett Tindale

Eylandt. In preparation for this work, he consulted with Baldwin Spencer in Melbourne, who gave him his own copy of the 1912 edition of *Notes and Queries on Anthropology* (Jones 1996b: 336). Jones describes Tindale's theoretical position as:

> . . . a salvage ethnographer from a natural science background . . . in the same company as Alfred Cort Haddon, Baldwin Spencer, or more appositely, Franz Boas. But despite sharing his [Boas's] relativist perspective, placing ethnographic objects within their specific cultural contexts, Tindale never repudiated evolutionist theory as Boas had done. In fact, Tindale's application of natural science taxonomic principles to ethnographic collections and exhibitions . . . more clearly echoed the career and achievements of the Smithsonian Institution's Otis B. Mason (ibid.: 337).

With regard to his responsibilities for the Pacific exhibits, Tindale had to deal with a lot of difficulties. Apart from the lack of space, the South Australian Museum had further problems. In the 1933 *Report on the Museums & Art Galleries of Australia*, sponsored by the Carnegie Corporation of New York, the lighting in the museum was criticized (Markham & Richards 1933: 43f.):

> In the Australian Museum a particularly notable exhibit is the New Guinea Ravi. In the Tasmanian Museum the aboriginal habitat case is delightful and attractive in every way. Somewhat similar cases are to be found in the Brisbane, Adelaide and Melbourne Museums, but the last two are spoilt by unfortunate lighting, resulting in excessive reflections.

After Waite expanded Stirling and Zietz's arrangement of specimens in the Pacific Cultures Gallery, little seems to have been changed until after World War II. Paul Lawson came to the Museum's team in 1936 as lunch attendant but after the War he was employed in the Exhibitions section. In an interview, 19 June 1997, he related:

> There was very little movement . . . in the layout of the specimens prior to the War. Except when Frank Tose from the Californian Academy of Sciences came out here, and he made quite a few suggestions about better visibility in the East Wing. He made some suggestions and we followed those, and in what we call the West Wing, now the North Wing . . . He made his suggestions on the grounds that eye-level material was valuable and [the] other was lost . . . The cases on the north wall that were above the main [wall] cases he considered were superfluous [because] he couldn't see the specimens. And we know that those specimens originally were put in those cases for visible storage because there was no other space around the area where you could store the stuff. When those cases were disbanded we used [them] in various ways, but the material had to be stored . . . I don't recall any dramatic changes until post-War days.

The War – Removal To Sleeps Hill Tunnel

Alarmed by the Japanese attack on Pearl Harbour on 7 December 1941, the South Australian Museum took steps to protect its collections in case of air raids. After some time looking for an adequate storage place for the collections' most valuable pieces, an abandoned railway tunnel was identified at Sleeps Hill, south of the City. However, to this day it remains unclear which parts of the collections were chosen for safe-keeping. In a letter to Hale dated 31 December 1941, Tindale wrote:

> In preparing the above list of material, it has been estimated that the only practicable method of dividing the general collections is to take each alternate specimen, or each alternate container, leaving the other in position. By this means,

> sufficient material will remain on display, and the division will ensure that the risk is halved.

Paul Lawson, who went to the War before the specimens were removed to the Sleeps Hill tunnel, and came back after they had been returned, understood that the division had been carried out on other grounds (Interview, 19 June 1997):

> They took any material off display that was considered extremely valuable. It couldn't all go, but the reference collections[12] . . . went up there because they are really the key.

This seems to be confirmed by the following excerpt from Tindale's letter to Hale, quoted above, which also gives an idea of the quantity of material that had to be transported:

> I have made an inventory of the material in this Museum which it seems desirable should be placed in safe keeping in a war emergency. I have divided the list into two, namely (a) Essential Documentary Records, (b) List of the Total Weights and Cubic Measurements (net), of the irreplaceable or unique specimens in the collection.
>
> In this survey I have taken into special account the Ethnological collections, most of which belong to peoples now extinct . . . Ethnology 700 Cub. ft. 6 tons; Ethnology Gallery Annexe 300 Cub. ft. 3 tons; Australian Ethnology Store 900 Cub. ft. 8 tons; Australian Crania 150 Cub. ft. 1/2 tons; Ethnological General Court 1200 Cub. ft. 10 tons.[13]

It is surprising that although this transport must have called for so much work, time and planning, few records of it can be found. One reason for this might be that the documents were lost during the disruptions of wartime, another that they are stored somewhere as confidential documents, or perhaps they are yet to be found in the still-not-completely-explored archives of the Museum.

In January 1942, Tindale left the South Australian Museum 'to act as an interpreter [in the R.A.A.F.] in the Japanese language of which I have rather extensive knowledge' (Tindale to Director Hale, 13 January 1942). In his absence, Harold Cooper was appointed on a part-time basis as Assistant Ethnologist (Hale 1956: 172).

Although nothing had been transported to the Sleeps Hill tunnel at the time of Tindale's departure, he must have been at least partially involved in the preparations for the transport, since we read in a letter by Hale which was written only about 10 days after Tindale's departure: 'It now seems certain that we will shortly be transferring a good deal of our material to the country. It is probable that some of our galleries will be at least temporarily closed' (Hale to Scott, Director of Queen Victoria Museum and Art Gallery, Launceston, Tasmania, 30 January 1942). The last sentence supports the belief that the exhibited collections were not moved entirely, otherwise he would not have used the word 'some'.

On 7 April 1942, Hale informed Tindale:

> We have removed most of the entomological collections and some of the ethnological to one of the pavilions in the National Park. We were lucky to get this as everything is being occupied by military camps. Apparently work has been well started in the Tunnel and we have all the rest of the ethnological material ready to go at a moment's notice. Cooper and Vogelsang have worked like Trojans on the packing job and, in fact, have both knocked themselves out.

On 18 May 1942, Hale reported in a letter to Professor Hill of the Medical College in Colombo, Ceylon that: 'The major part of our ethnological material is packed away for safekeeping and will not be available until after the war.'

Little is known about which galleries were closed and which objects remained on display during the time the specimens were stored in the Sleeps Hill Tunnel. The *Annual Report* 1942–43: 3 notes: 'Collections stored away from Adelaide as an air raid precaution and those in reserve in the Museum are regularly inspected and are in good condition.'

The specimens remained in the tunnel for two years. Then Cooper reported: 'all the ethnological material removed to Sleeps Hill some time ago has now been returned to the museum with the exception of six canoes' (Cooper to Hale, 24 May 1944).

After the disruption caused by the removal and subsequent return of the Museum's collections, it seemed like a good time to assess the Museum's situation:

> During this year the Board has devoted considerable time to discussion of possible post war extension of

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[12] 'Reference collections' are the type specimens with which all subsequent specimens are compared for identification; this term is normally used in relation to natural history collections not ethnographic collections. Lawson is unsure whether the ethnographic material was considered in the same way as the natural history material for the purpose of the removal.

[13] By comparison, the mammals were listed in this survey with merely 400 Cub. ft. 2 tons.

> the Museum. Lack of adequate exhibition and storage space became acute years ago, and the position is now extremely unsatisfactory . . . Exhibition space is so limited that justice cannot be done to displays illustrative of our fauna and of our aborigines . . . Particularly, one may mention our Ethnological collections which could be made a feature of a new Museum. Many of the 40,000 objects of this collection were secured years ago, and today it can be said that literally some of them are worth their weight in gold. Some of the material from the Pacific Islands for example cannot be duplicated. Portion of it is displayed in the old red brick Museum, but necessarily the specimens are placed close together in the cases with the idea of affording safe housing for as much of this valuable material as is possible. To the public such an arrangement is meaningless and these stored specimens alone could be spread out to fill a very large hall so as to illustrate by means of labels, maps and photographs, the life and interests of the Pacific peoples. This and other projects cannot be considered until vastly more floor space is available (*Annual Report* 1944–45: 3).

The problem of relying upon natural light for the viewing of exhibits is reviewed in the *Annual Report* 1945–46: 2:

> The need for adequate artificial lighting has been stressed again and again. In our State, conditions in the Museum buildings may be said to present a violent contrast, in that on summer days it is difficult to exclude the bright light, which causes irreparable damage to furred and feathered animals placed on exhibition, while on the other hand, in the winter months, when during the weekends the Museum is thronged, it is difficult to see some of the exhibits, and recently at 3.30 p.m. on a dull Sunday afternoon there was observed the ludicrous spectacle of a visitor striking matches in order to read some of the labels in the General Court [North Wing].

The conclusion drawn from this difficulty was that the light-wells in the East and North Wings would have to be filled in and electric lighting installed. This would have the bonus of greatly increasing floor space for the exhibits. But the money to fill in the East Wing light-wells would not become available for another twenty years, and to fill in the North Wing light-wells, almost another ten years after that.

Tindale's 'Rearrangement' Of The Pacific Gallery

In July 1946, Tindale returned from war service to the South Australian Museum and took over from Harold Cooper who continued as an Assistant. In addition, Harold Burrows was employed as Museum Assistant to further support Tindale.

During his time in the R.A.A.F., Tindale had collected a small amount of material from the Pacific region (the Markham Valley, and other parts of New Guinea and the Solomon Islands – see *Annual Report* 1946–47: 3). It is also probable that Tindale deepened his knowledge of Pacific cultures during his military service. In Tindale's *Report on State of Ethnological Collections*, prepared for the Director (7 November 1946), he attested that Cooper:

> has done a most excellent job in protecting the specimens, registering new material, and supervising the laborious tasks of packing and unpacking that half of the collection which was consigned to Sleeps Hill tunnel for safe keeping during the Emergency. Mr. Cooper also rearranged a large part of the Ethnological Gallery for temporary display . . . It will be noted that during the shifting of the specimens, many of the flimsily tied-on metal tags used in former years became detached, and it became unfortunately necessary to re-register some specimens as being without data.

In the *Annual Report* 1945–46: 3 can be read the following about Cooper's work: 'The interior of a number of cases was painted, their contents re-arranged, and additional labels and photographs added to make the exhibits more attractive.' However, it seems that this remark was made with reference to the Stirling Gallery (Australian Aboriginal) cases, not the Pacific cases (see Hale 1956: 172). Also it would be inconsistent with Tindale's stated reason for starting on the Pacific Gallery first (see below).

After the War, there was much disorder despite Cooper's work and everything had to be re-organized (Interview with Paul Lawson, 19 June 1997). Even before Tindale commenced on the installation of an Indonesian Gallery or took care of the Australian Aboriginal exhibits, he began re-structuring the Pacific Cultures Gallery. The reason for this can be found in the *Annual Report* 1946–47: 3):

> Although the Australian ethnological galleries need attention and should have had priority, the re-organization of the old ethnology gallery had to be hastened owing to the unfortunate use of low grade war-time carbon bisulphide, containing free sulphur, in the fumigation of the specimens. This caused the paint in the cases to darken. Painting was overdue since much of this portion of the gallery had not been decorated since 1894.

Paul Lawson recalled the Pacific Gallery cases as follows (Interview, 19 June 1997):

> The fronts of the cases, the woodwork, was black, . . . a French polish black. The insides of the cases were painted a flat grey . . . They were all changed when we started to work on the cases . . . Up until after the war they were still black.

The painting of display cases was not confined to the Pacific Gallery; there was a general change of colour throughout the Museum, from 'the old "museum colour"– a funereal black' (Hale 1956: 146, 189) to lighter colours.

In the Pacific Cultures Gallery, Tindale could not work with new ways of presentation as he did later for the 'Indonesian Gallery' because there were too many specimens. In fact, he added even more because the safest place for storage remained the display cases.

> Shortage of storage room space for these valuable specimens under cover necessitates the continuation of the highly undesirable practice of overcrowding the exhibition cases. In some instances, where perishable material has to be protected, even more material than was formerly present in the cases is being placed on exhibition. However, every endeavour is being made, by massing the exhibits, to preserve some semblance of spaciousness in the displays (*Annual Report* 1947–48: 3).

It is not certain if the colours for the inside of the cases were chosen to make the cases appear spacious despite the over-crowding or if this was just a fortunate side-effect. Paul Lawson said about this: 'It was done because the coloured backgrounds, [those] pale pastels, . . . looked more acceptable' (Interview, 19 June 1997).

The question that needs to be asked at this point is to what extent Tindale changed Stirling's and Zietz's arrangements. Were whole cases repainted but otherwise left unchanged?

Lawson rejected this supposition in the interview even though the wall case exhibits in the Pacific Cultures Gallery give the impression of a uniform style of display. Further, Tindale speaks repeatedly of 're-arrangement' in his correspondence; he also mentions the inclusion of completely new pieces: 'Opportunity is being taken to incorporate some of the more important accessions which have been lying in the storerooms' (*Annual Report* 1947–48: 3).

On the one hand, many of the wall case exhibits (e.g. X1, X2 – Papuan Gulf-Fly River; X3 – Central Papua; X4–X6 – Milne Bay; X7, X8 – Vanuatu; X9 – New Caledonia; X10–X15 – Fiji; etc) have only a few objects incorporated into them that came into the Museum after the early 1930s, suggesting that they may not have been much changed after the War. On the other hand, the Sepik/Madang/Huon Gulf cases (X25–28) incorporate large numbers of objects obtained just before, during and immediately after the War. This suggests that where the cases were more radically re-arranged, the exhibits were set up deliberately to conform to the older style of display.

Apart from new specimens, photographs and graphics also were introduced into the display cases. As at 1998, the old displays in the Gallery[14] featured more than 50 photographs and a number of graphics. As Hale (1956: 65) noted, the idea of using photographs in displays had a long history, dating back to about 1890:

> [Zietz] proposed that ethnological objects, such as those from Malaya, New Guinea and Fiji, could be 'explained' much better by the use of photographs showing them in use. He found it impossible to secure suitable pictures but the idea was reborn and carried out half a century later.

In a memorandum to Hale dated 9 July 1947, about the offer of an ethnological collection by a certain Miss Woods, Tindale wrote:

> Among the material from the Pacific Islands is much which is of special interest to us in view of the fact that we are re-arranging our collections from that area. There is an outstanding bird-beaked club from New Caledonia, which is better than one we possess.

In another letter from that time (Tindale to Rev. Barnes, 6 October 1947) he wrote: 'It is hoped that during the forthcoming re-arrangement of the New Guinea collections it will be possible to find a place for it [a model canoe from Barnes] on exhibition.'

In the *Annual Report* 1946–47: 3) we read:

> Activities of the department have been concentrated on the re-arrangement of the Pacific Island collections in the old gallery, together with their catalogue registration. Approximately one-quarter of the gallery has now been re-arranged after the cases had been painted . . . There is sufficient ethnological material displayed in this gallery alone to occupy twice the present space in order that it may be displayed more adequately. Removal of paint from the glass on the south side of the lantern [ie. glass roof] has improved the lighting conditions in the old

[14] That is, excluding the 1993 and subsequent additions to the Gallery curated by Barry Craig.

> gallery by more than 50 per cent. In dull weather the cases are still inadequately lighted and to complete the re-organization it seems essential that internal lighting of fluorescent tube type be installed.

In 1948, when Tindale was working on the re-arrangement for the third year running, he wrote (Tindale to Deland, 5 August 1948):

> we are at this moment re-arranging all our gallery collections of New Guinea material . . . We are trying to separate the ethnological specimens from the various parts of New Guinea to bring out the essential differences between such groups as the Sepik area, the Huon Gulf area, the Massim districts and the Gulf of Papua. In doing this we have naturally struck quite a number of problems on borderline material.

This quote makes it clear that Tindale not only added more specimens to the cases but worked on a new arrangement, at least in part of the Gallery, but he kept to the basic rule of exhibiting a representative series of object types arranged in a geographical sequence. He was not alone in his work:

> During the re-organization of the Pacific Island collections, the ethnologist received much advice and help in the re-identification of material from Rev. H. K. Bartlett, Rev. A. S. Webb, Mr. E. C. Deland, and others who have first-hand knowledge of the natives of these islands; as a result it is hoped that most of the material is now better known and more adequately labelled than formerly (*Annual Report* 1946–47: 3).

By 1948 the difficult and expensive work was not finished yet. Paul Lawson (Interview, 19 June 1997) described it as follows: '[the arrangement of specimens for] each case had to be laid out on the floor or on boards, then the actual putting in of the specimens was a slow job because they're all fragile.' The *Annual Report* 1947–48: 3 notes progress as follows:

> The ethnologist (Mr. N. B. Tindale) reports that the principal activity of the Ethnological Section during the year has been the re-organization of the Pacific Islands Ethnology collections exhibited in the old gallery. Approximately one-half of the gallery has been re-organized. This has involved the dismantling, card cataloguing of specimens, re-painting of cases and the re-installation of exhibits from Fiji, Solomons, New Britain, New Ireland, New Caledonia, New Hebrides and the Admiralty Islands.

The procedure was described by Paul Lawson (Interview, 19 June 1997):

> Tindale and Harold Burrows worked on that [the re-arrangement of the Pacific Cultures Gallery] and Tindale would tell Burrows what he wanted to put in there and then Burrows would try to arrange it the way he thought and then Tindale would okay it. So there were definitely changes. Admittedly some of those cases would resemble the previous arrangement very closely.

In 1949 the end came into sight at last:

> The re-arrangement of the South-west Pacific Ethnology Gallery by Mr. N. B. Tindale, assisted by H. Burrows and L. Wills, is nearing completion. By the addition of photographs, models and the use of bright background colours, they have transformed the presentation of the extensive collections (*AGMA – News Bulletin of the Art Galleries and Museums Association of Australia and New Zealand* No.3, September 1949; Sydney: 6).

In the *Annual Report* 1948–49: 4), relief about the imminent completion of the work can be felt:

> The ethnologist reports satisfactory progress in a major project of the section, namely the re-organization of the Pacific Island ethnological collections exhibited in the old red brick building.

FIGURE 7. Left half of wall case exhibit (X05 – Milne Bay Province, PNG) showing aesthetic of display arrangement.

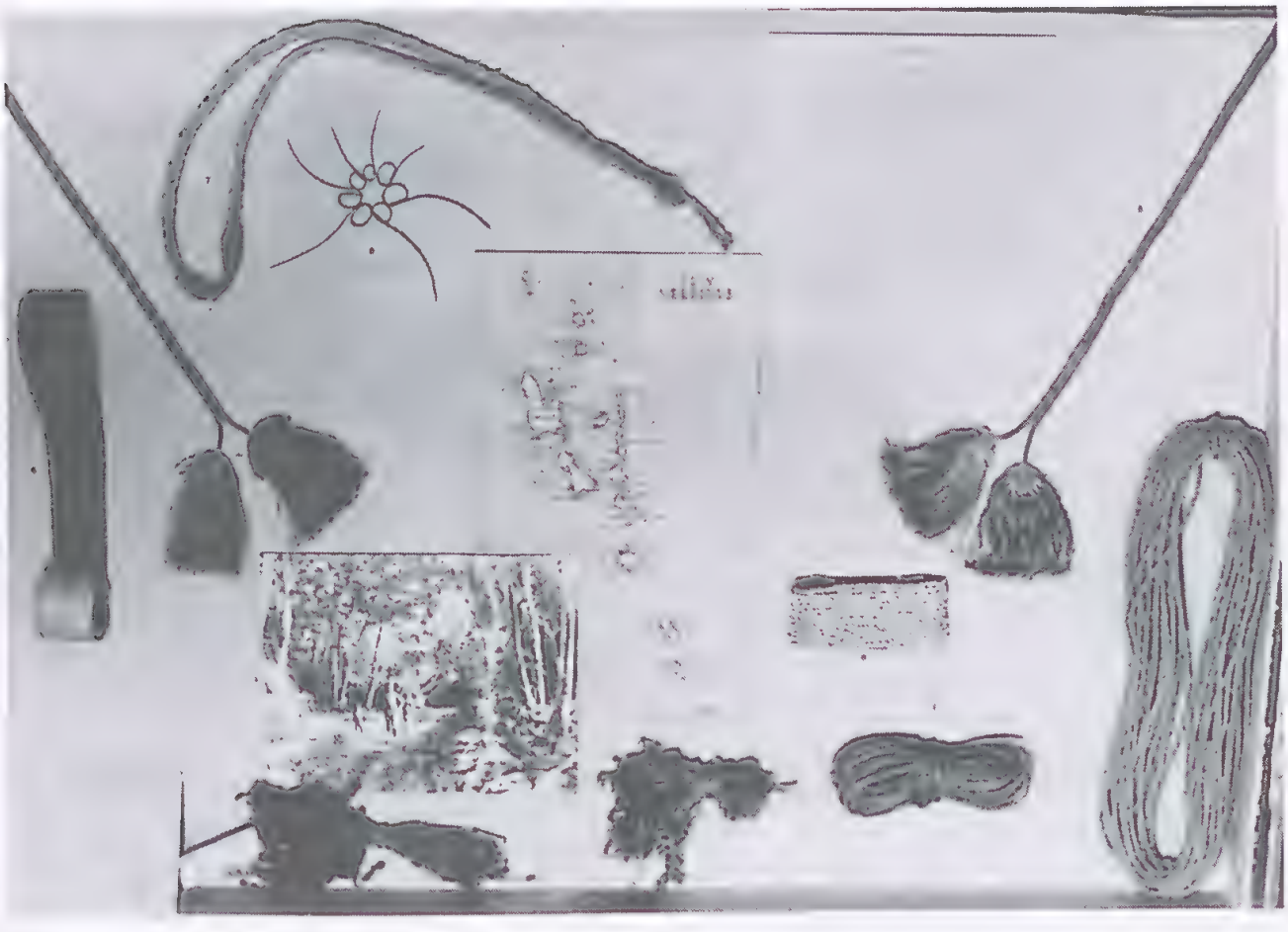


FIGURE 8. One of the window cases ('New Hebrides') installed by Norman Tindale in 1949 and removed in 1976.

> The greater part of the top floor of this gallery is now devoted to the display of our collections from New Guinea and the Melanesian portions of the Pacific Islands. Despite delays due to shortage of material and labour the interiors of almost all the cases are refurnished and the specimens newly installed. The Architect-in-Chief is installing fluorescent lighting in cases at the eastern end of the gallery. In continuation of this re-arrangement all plaster casts of fossil animals, formerly displayed on the walls over the main stairways, have been removed to other situations and the walls are being repainted.

In all, Tindale worked for more than four years on the re-arrangement of the Pacific Cultures Gallery. It must have been somewhat disappointing to him that he could not use new display methods like dioramas and that better contextualization was impossible due to lack of space but he did get fluorescent lighting for the wall cases.[15] The main task was to store as many specimens as possible in the cases, to renew the regional classification of objects (since Stirling had made many mistakes here) and to arrange everything in the most aesthetically pleasing way, which can be seen in the placement of specimens into triangular, parallel and diagonal patterns (Fig. 7). Further, 'In its basic arrangement, it still reflects the geographic organization imposed upon it by Edward Stirling during the 1890s' (Jones 1993: 29).

Work in the Pacific Cultures Gallery was not confined to the wall cases. In the table cases around the light-wells, and in the flat cases which were in front of the windows along the southern wall between the wall cases, Tindale used a then up-to-date display method. He arranged the smaller specimens, such as tools and ornaments, into geographically-defined series to supplement the wall case exhibits, presented other material on the basis of types of objects such as betel-chewing equipment and neck-rests, and other cases illustrated particular technologies, such as tapa-making. These displays contained more pictures with longer accompanying texts (Fig. 8). Above all they were not over-crowded. Rather, they seem spacious by comparison with the layout of specimens in the wall cases.

[15] It seems hardly credible that electric lighting was installed in the Museum only 50 years ago!

By the end of Tindale's work on the Pacific Gallery there were 4 200 specimens on display in 82 cases, 'making this one of the outstanding collections of its kind' (*Annual Report* 1949–50: 4). This compares with 3 000 on display today.

Tindale's exhibits in the Indonesian Hall,[16] which was opened in 1954 and dismantled in August 1982, were completely different to those in the Pacific Gallery:

> The Indonesian Gallery came after this [the Pacific Gallery] was completed . . . Display methods were different then. We did have a little bit of money, not very much, but we had a little bit more than we had when we were doing all this [Pacific Gallery] work – [which could use] only virtually petty-cash left over from something else (Interview with Paul Lawson, 19 June 1997).

In the Indonesian Hall, miniature dioramas were used; this constituted a different genre of display. Objects in the evolutionary sequence for which specimens were lacking were represented by replicas, models, graphics and photographic 'reproductions' (Hale 1956: 191).

The Post-Tindale Era

When Tindale retired from the Museum in October 1965, he left a young Assistant, Graeme Pretty, to continue his interest in the Pacific collections. Pretty, a History graduate from the University of Sydney, had joined the Anthropology staff in 1962 as Assistant Curator and was promoted to the new position of Curator of Archaeology in 1964. His interests included both Melanesian and Australian prehistory. Robert Edwards was appointed Curator of Anthropology when Tindale left and his interest was in Australian Aboriginal ethnography. A year after Edwards resigned in 1973, Pretty became Senior Curator of Anthropology and Archaeology.

In the late 1960s, the Director reported that because of increased overcrowding, extensions to the existing buildings were being considered (*Annual Report* 1969–70: 6 and *Annual Report* 1970–71: 6). The damage being caused to specimens by the sunlight coming through the glass roof was also of grave concern. Lawson pointed out a detail on an 1899 photograph of the table cases (Interview, 19 June 1997):

> Those black covers were to stop the light getting in because the light from up the windows [ie. from the glass roof] was quite devastating. It was ordinary glass which was painted with white wash on the inside. The surrounds leaked, the white wash came off, the water dripped down onto the cases, especially these flat cases. If they happened to be underneath where the drips were it would get in there . . . get in the cases. But the light was a real problem, until [the ordinary glass] was replaced with anti-UV glass and that did quite well. It was a greenish-blue tinge; that was an improvement.

To gain additional space in the West (North) Wing and eliminate the problems caused by sunlight through the glass roof of that Wing, the filling in of the light-wells was commenced. When the light-wells were filled in, floor space was gained.

> The closing in of the light wells in the West [ie. North] Wing allowed us to reopen the top floor to public exhibition late in the year [1972]. Some material which was stored away, usually in unsatisfactory areas, while this work was in progress, was able to be returned but the lower floor is still empty and the material originally housed there is distributed in a series of temporary areas (*Annual Report* 1971–72: 6).

As Paul Lawson reported (Interview, 19 June 1997), the reconstruction had originally been planned differently:

> It was decided to fill the light-wells in. And then it was going to be only a light floor, just to separate the two galleries [upstairs and downstairs] and to put some light material on. I was able to talk with the architecture and public buildings departments [and explain], 'We can't afford that space not to be walked on.' So they increased the strength of it.

The *Annual Report* 1972–1973: 9 optimistically stated:

> Reconstruction of the ground floor of the West [North] Wing is nearing completion, with the installation of air conditioning, a sprinkler system and glass for the display cases the largest outstanding tasks. Plans are being prepared for a general refurbishing of the upper floor [the Pacific Gallery] in which it is hoped to disturb only a

[16] The Indonesian Hall, located at the southern end of the top floor of the East Wing, was a bit of a misnomer and was later called the Human Cultures Gallery. Hale (1956: 191) states: 'The [Indonesian] Hall was designed to illustrate the earlier cultures of man and also more modern collections from South-eastern Asia. The last-named series have been arranged to show the origins of civilized man and his development through the stages of neolithic agriculture and the early Iron Age in the lands of South-west Asia . . .treating in turn the Indus Valley cultures, India, Malaya, Eastern Asia, Indonesia and the Pacific Islands around Australia'.

> minimal number of display cases around the walls and to create new exhibits in the central space, now occupied by mineral and fossil displays.

The intention not to re-arrange or add something new in the wall cases is clearly stated. Lawson's recall is consistent with this (Interview 19 June 1997):

> There was no dramatic re-arrangement of specimens or cases because of the light-well filling . . . Where we could, we used the [existing] cases . . . We didn't touch the contents . . . There was no re-arrangement of the contents.

That the Pacific Cultures Gallery looks the way it does today is due to the diplomatic skills of the museum's staff:

> [The air-conditioning] was put in after the floor came about . . . it wasn't in the original specifications but by a little bit of careful talking to the right people we were able to get the modifications. The whole project, as I admitted afterwards, would never have been accepted because of the cost. But because we had one little piece done at a time and then, because that was done, they had to do something else, it worked. But I was told never to come with that trick again (Interview with Paul Lawson, 19 June 1997).

These additional developments might have been why the *Annual Report* 1973–74: 9) explained:

> There have been unavoidable delays in the completion of the West Wing and Stirling Galleries. In the absence of a Curator (Senior) of Anthropology and because of some necessary building alterations, reconstruction of the Stirling Gallery has not proceeded. Attempts have been made to keep it open with limited displays, but these are far from satisfactory and do not reflect the wealth of our Aboriginal collections. A postponement, therefore, of work on the Pacific Cultures Gallery was necessary to keep it open, if we were to avoid effectively closing about three-quarters of the Museum.

These alterations which, apart from the air-conditioning, involved also the installation of a ceiling, spotlights and carpet, were delayed year after year and it wasn't until 3 October 1977 that Premier Dunstan officially opened the remodelled Pacific Cultures Gallery 'to coincide with the Annual Conference of the Museums Association of Australia' (*Annual Report* 1977–78: 22). However, although the Fossil displays had been relocated, the Minerals displays continued to occupy the central area of the Gallery.

Most of the table cases which since the late nineteenth century had been located around the light-wells remained (and remain today) but the window cases along the southern wall were removed in 1976 towards the end of the long period of reconstruction. Lawson has provided an album of photographs which show that the three air-conditioning units were installed along the southern wall by removing the flat window-cases, covering the windows and moving the wall cases closer together to provide the necessary space.

When the filling in of the light wells began, the vision was grander: 'It is planned . . . to redesign the entire Stirling (Aboriginal), Human Cultures, and Pacific Islands Galleries commensurate with the Museum's extensive holdings in these fields' (*Annual Report* 1972–73: 9). However, nothing on that scale happened either then or in the following quarter century, presumably because of lack of funding. Also, in 1975 the Premier had announced that a new Museum would be built, commencing about 1978, on a site occupied by a bus depot about a kilometre east of the present site. Perhaps it was not considered worthwhile allocating too many resources to a grand redesign if everything was to be moved to an entirely new Museum. But this never eventuated either.

One project that did add substantially to the Pacific Gallery was the purchase by The Friends of the South Australian Museum of 'a complete specimen of a traditional ocean going vessel from the Trobriand Island group of South-East Papua . . . [which] makes a splendid showing in the Pacific Islands Gallery' (*Annual Report* 1974–75: 19).

Although Pretty did go on two significant collecting expeditions to the Pacific region (in 1968–69 to the Southern Highlands of PNG and in 1972 to island Melanesia, accompanied by A. L. Crawford), he later concentrated more on an archaeology project at Roonka on the Murray River of South Australia. It is appropriate that his most obvious contribution to the Pacific Gallery was the addition of a small Melanesian Pre-history display in 1981. This display reflects the didactic genre typical of that period, utilising relatively few objects embedded in a large amount of text and graphics (Fig. 9). There was no attempt, however, to incorporate into the Pacific Gallery the Southern Highlands or island Melanesian material he collected.

Another, relatively minor change in the Pacific Cultures Gallery took place in 1986. During the 1970s reconstructions in the North Wing, a lift had been built at the northern end of the East Wing but a stop at the Pacific Cultures Gallery had not been included. In the mid-eighties this was added at last, which resulted in a loss of

FIGURE 9. 'Melanesian Pre-history' display installed by Graeme Pretty in 1981.

space for the Huon Gulf exhibit in the north-east corner of the Gallery. A new arrangement for the smaller case was designed by Sandy Hanson (Interview with David Kerr, 20 June 1997). The display technique chosen for this case stands out from that of other cases in the Pacific Cultures Gallery by its use of glass shelving and a more spacious arrangement of specimens but the use of minimal labelling was consistent with the old displays.

During the early 1990s, the greatly expanded Museum shop was squeezed into the central space on Level 3 adjacent to the main stairs. During that time the Trobriand *kula* canoe and the surrounding table cases were moved from the western to the eastern end of the Gallery to join the one-third-scale Rogea (Massim) hut and its surrounding table cases; the Mineral exhibits were moved to the western end.

The Last Five Years

By the time the Pacific Arts Association conference was held in Adelaide in 1993, the shop had moved to its present location in the space vacated by the Director and Administration at the south end of Level Two in the East Wing. The Trobriand canoe and surrounding table cases were returned to the west end of the Gallery and the Mineral exhibits to the centre; the Director and Administration relocated to the renovated Armoury Building immediately north of the Museum's North Wing. The wall cases also received some attention—the geographic labels on some of the cases were changed to reflect the political status of recently independent nation-states (e.g. Vanuatu) and the Vanuatu exhibit in the Bridge Case[17] (which included a large number of over-modelled and painted skulls) was removed and a series of model Melanesian canoes placed in it to complement the adjacent Trobriand *kula* canoe but there was minimal, even incorrect, information supplied about these canoes.

There have been other changes to the Gallery in recent years. In late 1992, Barry Craig was contracted to go to New Ireland and New Britain for seven weeks. His objective was to identify

[17] The 'Bridge Case' was so named as it was located on the section of flooring above the central foyer of the ground floor of the North Wing, separating the two sections of the light-well. This case appears to have been in this location since the 1890s.

FIGURE 10. 'La-Sisi' malangan canoe display installed by Barry Craig in May 1997.

two men from each area to come to the Pacific Arts Association's 5th Symposium, to be held at the South Australian Museum in April 1993. They were to bring and dance masks from those two areas—masks that would match masks obtained by the Museum 75 years earlier (Craig 1993, 1994, 1995). The display, in a large eastern wall case, of a rare, double-headed Sulka *hemlaut* mask from Wide Bay, New Britain, had been almost completely obscured by a wide range of other material from Papua New Guinea. These objects were cleared and smaller Sulka masks collected by Craig in 1993 were displayed alongside the *hemlaut* mask with photographs and text. A *hemlaut* mask he purchased during the trip was danced into the Gallery and mounted opposite the old mask with two panels of photographs, a map and information. An information sheet was produced and is available free at the exhibit (and also on the Museum's Home Page).[18]

Similarly, the New Ireland exhibits were slightly modified by removing two *malangan* from positions in the wall cases where they could barely be seen and placing them in a table case in the space opposite, along with a selection of material collected by Craig, explained by two panels of photographs, a map and information.

To avoid offending Pacific Islanders at the PAA Symposium, the Director (Dr Chris Anderson) decided to have black cloths suspended in front of, or laid over, any skulls or other skeletal material on display in the Gallery. These cloths have recently been removed.

In December 1995, Barry Craig was appointed Curator of Foreign Ethnology. He was a graduate in Social Anthropology from the University of Sydney strongly influenced by the work of Bryan Cranstone of the British (later Pitt Rivers) Museum (Craig & Hyndman 1990: iii–iv) had extensive experience in Papua New Guinea since 1962 and had been Curator of Anthropology at the PNG National Museum during 1980–83. This was the first time a position had been created at the South Australian Museum to care exclusively for the non-Australian (i.e. 'Foreign') ethnographic collections.

[18] www.samuseum.sa.gov.au

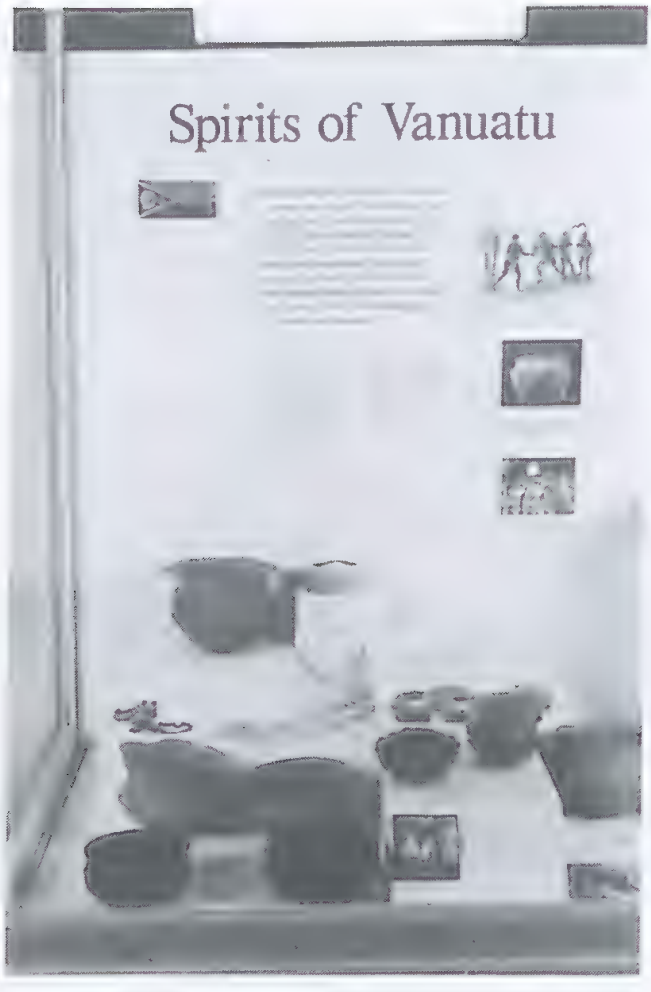


FIGURE 11. Part of 'Spirits of Vanuatu' display installed by Barry Craig in March 1998.

In 1996, Craig was responsible for a display of 42 photographs which were mounted on the large panels which conceal the three air-conditioning units along the southern wall of the Gallery.[19] These photographs had been taken in the Papuan Gulf area, New Guinea and the Solomons by an Oil Exploration geologist/surveyor, Ernest Sterne Usher, in 1914–16. An information sheet was prepared for this exhibit as well. Three large Papuan Gulf masks, removed from the Sulka *hemlaut* case in 1993, were set up opposite the Papuan Gulf wall cases.

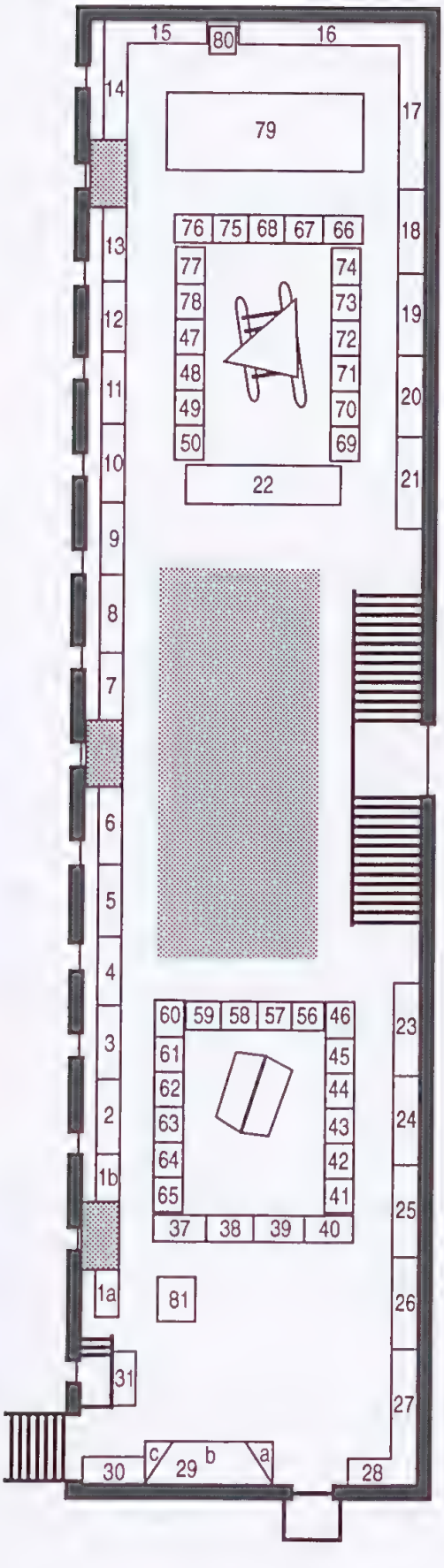
In 1997, Craig arranged the borrowing and installation of the privately-commissioned, 8-metre-long La-Sisi Malangan Canoe (Fig. 10); additional New Ireland material was displayed in association with this exhibit. Again, an information sheet was produced.

The most recent changes and additions to the Gallery were associated with an event in March 1998 timed for the Adelaide biennial Festival of Arts. This required Craig to go to Vanuatu to identify two men to come to the Museum and repaint a large Ambrym slit-drum (A.74765) donated to the Museum in 1996. The drum was installed in the main foyer of the Museum along with a tree-fern grade figure (A.74757) collected by Craig in 1997. This took place as a public event and included pork and vegetables cooked in a ground-oven and supplemented by *kava*, a beverage considered essential for all ceremonial events in Vanuatu. The model canoes were removed from the Bridge Case and a display of Vanuatu material took their place. This exhibit (Fig. 11) was designed to demonstrate the continuity of Vanuatu traditions by displaying pots, mats, musical instruments and other material collected by Craig corresponding to pieces obtained by the Museum 100 years previously. An information sheet was produced for this display.

A plan to redevelop the Aboriginal exhibits in the Museum, to be completed in the year 2000, required that the Pacific Gallery be moved to another space. However, in addition to certain design considerations, estimates of the cost of moving the Pacific exhibits and restoring the interior of the Gallery to its Victorian style, including the removal of the ceiling, proved too great for the amount of money provided and this part of the plan was dropped and the New Aboriginal Cultures Gallery is now being developed in the bottom two levels of the East Wing.

It now remains to find modest resources over the next several years to progressively upgrade the Pacific Gallery (Fig. 12) and provide more information through several levels of interpretation of the material on display, while maintaining most of the wall case displays as they have been since the late 1940s (in some cases possibly since the late 19th century). The floor case displays will be changed considerably to provide more information about various technologies and types of objects on a comparative basis. Concurrently, the exhibits in both wall and floor cases will be utilised to explain the nature of the relationship between South Australia and the

[19] This exhibit was suggested by Scott Bradley, contract photographer for the Museum, and much of the research on this collection was carried out by Grahame Pike (see Pike & Craig 1998).



0 metres 10 → N

1 a, 1b	Papuan Gulf
2	Western Papua and Torres Strait
3	Central Papua
4	South-east Papua
5 – 6	Milne Bay Province, Papua
7 – 8	Vanuatu
9	New Caledonia
10 – 15	Fiji
16 – 17	New Ireland
18 – 19	New Britain
20 – 21	Solomon Islands
22	Spirits of Vanuatu
23	Santa Cruz
24	Admiralty Islands
25 – 27	Sepik Region
28 – 29a	North-east New Guinea
29b	Sulka, New Britain
29c – 30	Papuan Gulf
31	Melanesian Pre-history
37 – 40	Betel-chewing equipment, PNG
41	Headrests, PNG
42 – 43	Tapa cloth, PNG
44 – 46	Massim region, S-East Papua
47 – 50	Vanuatu
56 – 57	Mountain Papuans
58 – 59	Papuan Gulf
60 – 63	Sepik-Ramu-Madang, PNG
64 – 65	Stone tools, PNG
66 – 68	Fishing, PNG
69 – 74	Shell ornaments and tools
75 – 76	Fishing, PNG
77 – 78	Maori, New Zealand
79 – 80	New Ireland and La-Sisi Canoe
81	Sulka, New Britain

FIGURE 12. Plan of the Pacific Gallery as at March 1998.

Pacific through the agency of the many people—missionaries, government officers, soldiers, scientists, etc.—who were the collectors (Jones 1993).

With the removal of the Minerals exhibits from the centre of this space, it is hoped that a display of New Guinea highlands cultures can be added, a project towards which Tindale was moving in the 1940s but was unable to bring to fruition (Fitzpatrick 1999: 183, 202). There may be space also for a more comprehensive exhibit dealing with Pacific prehistory, especially that of the Austronesian origins of Polynesia, with associated exhibits of Polynesian and Micronesian material, at present not on display. The model canoes and maritime trade articles in the collections will provide the basis for a display on the significance of maritime trade in Melanesia and its origin in the cultures of the Austronesians several thousand years ago.

The South Australian Museum's Pacific Gallery is the largest and most comprehensive display of its kind in Australia. Visitors to the exhibits value the old style of display and the large number of objects available for viewing. With careful use of modern technologies, the present lack of information in the Gallery can be addressed, as has already commenced with the Sulka, New Ireland and Vanuatu exhibits. The linking of these refurbishments with performances conducted by people of the areas from which the objects came, will become standard procedure. The opportunity also exists to take back photographs of objects to the descendants of those who made these objects, to obtain more information and to provide the basis for future co-operative use of these things, including repatriation.

What was once an asymmetric relationship between tribal peoples and foreign curio and museum collectors can become more balanced, and projects can be developed (such as the 1993 New Ireland/New Britain and 1997/8 Vanuatu initiatives described above) which bring the museum's public into direct relationship with the descendants of those peoples. The covert messages conveyed by the old, essentially 'Victorian', style of exhibits in the wall cases can be objectified and the Gallery can then function also as a museum within a museum.

Acknowledgments

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References

CRAIG, B. 1993. Sulka Danced Sculpture. *Artlink* **13**(2): 46–49.

CRAIG, B. 1994. Masta Bilong Faiawud. *Paradise* **103**: 29–31.

CRAIG, B. 1995. Following the tracks of Edgar Waite in New Guinea for the Pacific Arts Symposium in Adelaide. *Records of the South Australian Museum* **28**(1): 33–52.

CRAIG, B. and HYNDMAN, D. (eds) 1990. 'Children of Afek. Tradition and Change among the Mountain-Ok of Central New Guinea.' Oceania Monograph No.40. Sydney: University of Sydney.

FERGIE, D. 1997. 'The Pacific Cultures Gallery, South Australian Museum. An Analysis and Assessment of Cultural Heritage Significance.' Report submitted to the State Heritage Branch, Department of Environment and Natural Resources. Adelaide.

FITZPATRICK, P. 1999. The A.P.H. Freund Collection of New Guinea artefacts held by the South Australian Museum. *Records of the South Australian Museum* **31**(2): 181–214.

HALE, H. M. 1956. The First Hundred Years of the South Australian Museum, 1856–1956. *Records of the South Australian Museum* **XII**: 1–225.

JONES, P. 1992. The life of a 'Museum Man' – Edgar Waite's diaries as an historical source. *Records of the South Australian Museum* **26**(1): 73–75.

JONES, P. 1993. A Brief Survey of the South Australian Museum's Pacific Collections. *Pacific Arts* **7**: 20–31.

JONES, P. 1996a. Obituary. Norman B. Tindale. *Records of the South Australian Museum* **28**(2): 159–176.

JONES, P. 1996b. '"A Box of Native Things": Ethnographic Collectors and the South Australian Museum, 1830s–1930s.' PhD Thesis, University of Adelaide.

MARKHAM, S. F. and RICHARDS, H. C. 1933. 'Report on the Museums and Art Galleries of Australia.' London: The Museums Association.

PIKE, G. and CRAIG, B. 1978. The Usher Collection of Papuan Photographs in the South Australian Museum. *Records of the South Australian Museum* **31**(2): 215–253.

Reports of the Board of Governors of the Public Library, Museum and Art Gallery of South Australia (annually, 1884–85 to 1939–40). Adelaide.

Reports of the Museum Board (annually, 1940–41 to present). Adelaide: South Australian Museum.

THE CHIEFS OF KIRIWINA

RALPH S. LAWTON

LAWTON, R. S. 1999. The Chiefs of Kiriwina. *Records of the South Australian Museum* 32(1): 91–118.

This paper is a socio-linguistic study of chiefly status in the northern portion of Kiriwina, the largest of the Trobriand Islands off the eastern end of New Guinea. It describes chiefly privilege, chiefly authority and the chiefly hierarchy. Reference is made to relevant items of material culture held in the collections of the South Australian Museum. An appendix describing the choice of certain Kiriwinan terms for use in Bible translation reveals the subtlety of the terminology used by Kiriwinans when referring to chiefly matters.

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Introduction

This study of Kiriwinan chiefly hierarchy was originally prepared in 1968 for presentation at a translation workshop conducted by the Bible Society in Banz, Papua New Guinea, and has never been published. The initial purpose was lexical research.[1] However it developed into a study of the distinguishing features of the Kiriwinan chiefly hierarchy with special reference to the lexicon of chiefly terms and the semantic reference of authoritarian words, and as such was presented at a meeting of the Anthropological Society of South Australia in June 1996. At the suggestion of Barry Craig, Curator of Foreign Ethnology at the South Australian Museum, it has been enhanced to include reference to relevant artefacts in the collections of the South Australian Museum.

This hereditary order of chiefs in Kiriwinan society has been commented on by many anthropologists, particularly those who have carried out research in the Massim region of eastern Papua. Seligman (1910: 663) commented that 'chieftainship appears to be more highly developed in the Trobriand Islands than elsewhere in British New Guinea' and noted many of the rights and privileges peculiar to chiefly status (ibid.: 695ff.).

Bronislaw Malinowski, primary chronicler of this culture, makes frequent reference to the chiefly order (e.g., 1922: 10, 24f.; 1932: 52; 1935: 80) but his published works do not include any specific study of the things which mark rank in the chiefly hierarchy, or the level of authority borne by different ranks. He comments that his brief outline of chieftainship (1935: 38–40) 'cannot do justice to the complexity of the subject'.

A more recent scholar, Annette Weiner, has made a clear reference to the chiefly order (1976: 45), citing its hereditary nature, its 'effective means of rank separation' through 'the paraphernalia of decorations and social and physical taboos', and the political importance of polygamy for the highest ranks. She lists on the same page the names of those who have made significant reference to the subject.

In this paper I have tried to delineate the order of rank in the Kiriwinan chiefly hierarchy, with special attention to two marks of chiefliness — *karaiwaga* or authority (both ancient and modern) and *koni* or privilege at its various levels for each rank. I have not given special attention to the taboos peculiar to chiefs. So far as I know, the hierarchy has not been delineated in this way by any other student of Kiriwinan society.

My main sources were two men of high rank within the Tabalu sub-clan of the Malasi clan. The first of these, and the one who encouraged me to make this study, was Antonio Lubisa Bunaimata (Fig. 1). Antonio had refused to yield to pressure

[1] Its purpose was to show how chiefly concepts and the vocabulary attached to chiefly rank had influenced my work as a Bible translator. I had intended to omit that part in this presentation. But as it is relevant to translation theory and could be of interest to linguists, I have included it as Appendix V.

from those wishing him to become chief of the Kavataria village community because he preferred to retain his place as a pastor within the (then) Methodist Church in Kiriwina. The second, recommended by Antonio, was Tolosi, a blind Kiriwinan who was an acknowledged repository of reliable information and legend relating to chiefly status in Kiriwinan society.

Together Antonio and Tolosi discussed the various questions I posed about chiefly sub-clans and the various degrees of authority and privilege which traditionally belonged to each family. The discussions occupied about twenty hours over several meetings during 1967 and this paper seeks to present their conclusions and pronouncements. It is acknowledged that certain matters may have evolved over the past three decades and I do not want the reader to assume that this paper refers to Kiriwinan chieftainship as it exists in the late 1990s, nor that it represents the view of chiefly matters held by others than Antonio and Tolosi, though there will of course be many consistencies.

Kirwinian Society

The Kiriwina people live in the Trobriand Islands at the northern fringe of Milne Bay Province, Papua New Guinea. The population on Kiriwina when this paper was first researched in 1967 was about 13 500 but by 1996 had almost doubled to 26 000. Also, there are at least 4 000 Kiriwinans living in various urban centres in Papua New Guinea.

One language only (with dialect variations) is spoken throughout the Trobriand Islands and in the Lusancay and Marshall Bennett islands nearby. This linguistic uniformity is not common in polyglot Papua New Guinea society and is especially unusual for island-dwelling communities, as geographical divisions usually provide conditions which ensure linguistic diversity. As an example of this, in the much larger D'Entrecasteaux Islands immediately south of the Trobriand Islands, a linguistic survey conducted in the 1960s recorded 19 separate languages for a population of around 35 000.

The residents of the Trobriand Islands are more correctly to be called the Kilivila people but due to an early mis-naming of the main island of the group as the island of Kiriwina, and also for what could be called political expediency,[2] the people are generally known as Kiriwinans; indeed, many *mina Kilivila* today prefer to use it of themselves and I will so refer to them here.

In order to appreciate the social order in which the class system of Kiriwina is set, it is necessary to look at both the clan groupings into which the whole society is divided and at the sub-clans which form a chiefly hierarchy within each clan group. These two divisions of the society may be seen as a vertical (clan) and a horizontal (class) division which uniquely defines the place of each member of society.

The Clans of Kiriwina

The matrilineal clan grouping is the vertical dimension which divides the whole of Kiriwinan society into four separate groups. Each clan is further divided into a number of matrilineal sub-clans. I will look now at these two social groups. A clan is called *kumila* and a sub-clan *dala*.

A *kumila* may be defined as a group of *dala* held together by certain customs or obligations; these customs or obligations separate them from other *kumila*. One clan is related to another by an exogamous marriage relationship. Each *kumila* has a pair of totem animals. The *kumila* in Kiriwina are four in number. Their names are Malasi, Lukuba, Lukosisiga and Lukulobuta.

The Malasi has the dove (*bubuna*) and pig (*bunukwa*) as its totem animals. Its chiefly *dala* include most importantly the Tabalu, from which the so-called 'paramount chief' of Kiriwina comes. Its two other chiefly *dala* are Osusupa and Bwaitaitu.

The Lukuba has the sea eagle (*mluveka*) and the dog (*kaukwa*). Its chiefly *dala* are Mlobwaima, Mwauli and Tudava.

The Lukosisiga has the coconut parrot (*karaga*) and the snake (*keiyuna*). Its chiefly *dala* include Kwainama, Sakapu (now probably extinct, their place being taken by Wabali — see footnotes 19

[2] One of the locally-recognised political divisions is the Kilivila area and this is both numerically and politically the strongest part of Kiriwinan society. I believe that other areas of Kiriwina feel threatened today if they are all collectively referred to as 'mina Kilivila' (people of Kilivila). I once asked a man who lived in the Kuboma area, which abuts the southern border of the Kilivila area, whether he preferred to be called 'Tolela Kilivila' or 'Tolela Kiriwina' (a man of Kilivila or a man of Kiriwina) and he replied unhesitatingly 'Kiriwina!' When I asked him why, he muttered to himself for a while, and then replied, 'Because Kiriwina is the name on the map!'

TABLE 1. Structure of Kiriwinan Society

	Malasi clan	Lukuba clan	Lukosisiga clan	Lukulobuta clan
gweguya or chiefly families	**Tabalu** **Osusupa** **Bwaitaitu**	**Mlobwaima** **Mwauli** **Tudava**	**Kwainama** **Sakapu (Toliwaga),** but now **Wabali** **Kailai** **Kulutula**	**Kaitotu** **Kabata**
tokai or commoners	**many**	**many**	**many**	**many**

and 20), Kailai and possibly Kulutula. The Sakapu *dala* bore the honorary title of Toliwaga, conferred upon it by the Tabalu in the forgotten past.

The Lukulobuta has the banana parrot (*gegila*) and the goanna (*kailavasi*). Its chiefly *dala* are Kaitotu and Kabata.[3]

Within each clan group there are also a number of non-chiefly or 'commoner' *dala*. I have named only chiefly *dala* because they are the cross-clan group I have referred to as horizontal. Because marriage relationships are exogamous, and because chiefly *dala* only marry into other chiefly *dala* (never into the *dala* of *tokai*, the commoners), there is a clear division of Kiriwinan society across all clans.

The most important feature of the clan grouping is the marriage relationship and the children which issue from the women who take their place in the clan's membership. The marriage bond is, as I have stated above, exogamous, which means that the husband is not a member of his wife's clan and children take their clan membership from their mother.

The exogamous relationship by which the four clans are related is said to be breaking down these days, although most people feel that marriages within the clan are improper. In the past, marriage or sexual contact of any sort within a clan was seen as shameful or incestuous and if brought to public attention was often followed by a public confession and suicide attempt (usually successful).

Apart from the public scrutiny of relationships in marriage, clan membership of any person has no particular prominence except when clan membership is terminated by death. However at the time of death the entire village is thrown into turmoil because of clan obligations in mourning customs.

The three clans who have not been depleted by death must immediately do everything necessary for the proper conduct of burial and associated acts. It is in their interest to do so, for the bereaved clan is obliged to pay back every act of grief and every service to the deceased. Every tear shed, every clod of earth moved for the burial, every finger laid on the shroud when the body is moved, is carefully noted and acknowledged in subsequent distributions of food, betel nut, pork, etc. Such mortuary distributions are called *kaimelu*.

Then the clan in mourning has a second distribution (called *yawali*), strictly within the clan, when the entire possessions of the former household of the deceased are distributed. The widowed partner owns nothing and must return to his/her own clan. In this distribution, not only the pots, tools, wealth items, etc. are distributed, but the very house in which they lived may be dismantled and distributed.

A third mortuary distribution is conducted by the women of the clan when skirts and skirt-making material ('women's wealth') are distributed in payment of obligations. This is called *sagali paila baloma* (Weiner 1976: 91).

A fourth mortuary distribution, the last one, takes place at harvest time[4] when either the food

[3] My two colleagues were unsure as to whether these two are separate *dala* or whether they come from one older *dala*. I could not find anyone else who could clarify this for me.

[4] Kiriwina is a yam culture with a specific annual harvest.

from the garden planted by the deceased, or the food produced by a special garden planted by clan members after the death, is distributed. In this distribution of food, all obligations of the deceased and his/her relatives are finally settled.

This exchange is usually within the year of death but may in some cases take place several years after the death, as the clan will wait until a good enough harvest is gathered to enable them to do sufficient honour to the deceased. In such cases the unfortunate bereaved must continue to wear and display the signs of mourning[5] for years, to do due reverence to the deceased until that final distribution is concluded. This final exchange is called *sigiligula*.

Thus the clans of Kiriwina are involved in a continuing succession of mortuary exchanges and counter-exchanges, so much so that people may be more important and socially significant in death than they ever were in life.

The Sub-clans of Kiriwina

Each of these four clans (*kumila*) is further divided, as noted above, into sub-clans (*dala*); and a fundamental division into chiefly and non-chiefly sub-clans must be seen as a horizontal division of the whole society into chiefly (*gweguya*) and commoner (*tokai*) classes (Table 1). All four clans are affected by this division.

A *dala* is not a family unit of parents and children but a group of matrilineally-related people who can trace their relationship to a common mythical ancestor. Each *dala* (more especially, chiefly *dala*) is able to point to one geographical point of origin, perhaps a cave or some topographical feature, which is the place where that ancestor first came into Kiriwina. This place is called the house (*bwala*) of that *dala*.[6] Needless to say, the ability to recount genealogies and long lists of descent from the original ancestor is an important mark of authenticity for any one *dala*. Surprisingly, I do not think that anyone has done any field-work on gathering these genealogies (*liliu*), even though they would be important oral sources for Kiriwinan prehistory.

I found it difficult to get information on commoner *dala*. There was a general feeling amongst chiefly informants that there were very many such *dala* but that most *tokai* did not know the name of the *dala* to which they 'belonged'. My informants did name eleven *dala* of the *tokai*, but they knew of these because they were special families which had certain privileges recognised by the *gweguya*. They did not know (or would not name) the sub-clans which had no special privileges or authority.

The Chiefs Of Kiriwina

I now proceed to examine the chiefly *dala*, which is the main concern of this study. The whole group of chiefly *dala* is collectively referred to as the *gweguya*, which is the plural form of *guyau*, 'chief'.

The *gweguya* of Kiriwina are made up of the ten or perhaps eleven *dala* shown in Table 1 above. Those shown high in the list for each *kumila* are of a higher rank than those placed below. I must say two things about this group of sub-clans.

A Separate Social Set

First (as stated above), the *gweguya* are a separate social set, having more to do with each other across clan boundaries than they do with commoners within their own clan. This is reinforced by the fact that the *gweguya* only marry into sub-clans that are chiefly. This marriage relationship holds the *gweguya* together. A parallel may perhaps be seen in the royal houses of Europe in the 18th–19th Centuries. Although conscious of the differing levels of privilege and authority (noted below) yet they are a homogeneous social unit within Kiriwinan society.

This homogeneity was demonstrated in the 1960s when, at the time of the first formation of a

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[5] These include such things as a shaved head, blackened unwashed body, mourning beads and skirts, etc.

[6] I was once granted the privilege of visiting the *bwala* of the Tudava sub-clan. (Tudava was a legendary hero who slew the cannibal giant Dokanikani and liberated Kiriwina.) The track to the sacred spot was significant at almost every point with various legendary associations being attached to a mound or a rock. At one point my guide pointed out a flat area in a grove of trees as 'the house of the Tabalu sub-clan'. After a rough journey through rugged limestone formations we came to the cave which was said to be Tudava's *bwala*, the point of origin of the Tudava sub-clan. Lovely grottoes sparkled before our torches, encrusted with stalactites and stacked with heaps of ancient human bones, some completely encased in limestone from the dripping water. These were said to be the bones of ancient Tabalu ancestors, whose *bwala* I had been shown earlier.

Local Government Council for all Kiriwina, the Government was able successfully to convene a parallel Council of Chiefs as an advisory body.

Secondly, it depends on whom you ask as to whether all sub-clans in this group may be considered chiefly. If the question is directed to a *dala* fairly low in the pecking order, such as Tudava, then certainly all of these sub-clans are chiefly, only differing in the amount of privilege or weight of authority. If however the same question is asked of a Tabalu chief (as I did on one occasion ask the then paramount chief Vanoi of Omarakana), only the top three (Tabalu, Mlobwaima, Wabali) and maybe a fourth (Kwainama) are truly *gweguya*, whereas the others are merely *tokwaraiwaga* (people with authority).

In this paper, however, I am assuming that all the families listed are of chiefly rank, for each has a definable level of authority and a recognised set of privileges, and I see these two distinctive features (authority and privilege) as the things which determine membership within the chiefly order. Here it is my purpose to show the different level of privilege and authority that each *dala* is accorded by Kiriwinan society.

The word *gweguya* is the plural form of *guyau*, 'chief', and refers to everybody within the various chiefly *dala* whether they hold the place of a village chief or not.

Those who become village chiefs rank high in the *liliu* ('legend') of their *dala*. Certain villages are traditionally occupied by chiefs of a particular *dala*. For example, the high-ranking Tabalu *dala* traditionally hold the office of chief in the villages of Omarakana, Gumilababa, Tukwaokwa, Kavataria, Mlosaida, Sinaketa and Kaduwaga,[7] while another *dala* would traditionally provide the chief of a different set of villages.

The Two Distinctive Features of a Chief

The distinctive features of the *gweguya* recognised by all Kiriwinan society are two, which they call *koni*, 'privileges' and *karaiwaga*, 'authority'. A description of the range of meaning attached to these two will show the total distinctive field of the *gweguya* of Kiriwina.

The feature of *karaiwaga* belongs only to the one who holds the position of *guyau* or village chief, whereas the feature of *koni* is shared in some measure by all the members of the chiefly *dala*. But the full glory of *koni* only belongs to the actual chief of a village; only the chief is able to put on or exercise all the rightful marks of his class. Other members of his *dala* benefit from the same privileges, but in a lesser degree, with due regard being paid at all times to the principle of *kautuwota* referred to below.

Thus, in the comments on *koni* below, I will frequently refer to the chief as the recipient, because he is the highest-ranking one present; but in a lesser degree the remarks will apply to other *gweguya*.

Chiefly Privilege

Koni as a word in general use means a burden carried on the head or shoulders; or, the particular part of a task for which one is held personally responsible. As applied to the *gweguya, koni* has reference to chiefly privilege, rights and responsibilities which they as chiefs are entitled or expected to bear.

Under the heading of *koni* therefore I group the wearing of certain adornment, adornment of a house, certain aspects of personal behaviour or bearing, the right to certain yams, the receipt of an annual tax, certain special chants and honours due to him on occasions, the right to a number of wives, and the elevation of the chief's person above others near him. I now consider the details of these *koni*.

Body Ornaments

The wearing of ornaments or decoration of the body is one of the facts of life for every Kiriwinan, whether chiefly or not. However, certain ornaments are reserved for the *gweguya* as their particular right or privilege. Alternatively some particular modification is made to an ornament commonly worn by all *tokai* which makes it the particular prerogative of the chiefly sub-clans.

Personal adornment is generally referred to as *kala katububula*, 'his adornment' (Fig. 2). On an occasion when a chief is dressed in all his finery, this highly decorated state is

[7] The villages of Oyuveyova and Oluvilevi are traditionally Tabalu also, but for a number of reasons are currently under the rule of a chief from a different *dala*. See the distribution of these villages under Tabalu chiefs in the map in Appendix IV.

described as *kala kalugologusa*, 'his splendour' (used only of a regnant chief).[8] The various items of personal adornment for general daily wear or for dancing decoration of the *gweguya* are listed in Appendix I.

House Adornment

The second *koni* item is the practice of adorning houses with boards painted in a particular pattern, or by attaching various other ornaments. Such a practice is exclusively the right of the chiefly sub-clans. The total process of decorating a house is called *bomileilai*. The house of a high-ranking chief, when completely decorated and ornamented, is spectacular and colourful. Such a house is called a *ligisa*. It is on the *ligisa* that the various house ornaments listed in Appendix II are displayed.

Many of the same house decorations may also appear on the chief's yam-house (*bwaima*) (Figs 3, 4) and the chief's council house (*buneyova*).

In addition, all of the *gweguya* resident there have the right to use some ornament and some painted decorations on their houses and their *bwaima* (the quantity of decoration being determined by the comparative standards known as *kautuwota*, referred to in the next paragraph).[9] But only the chief who rules a village has the right to have and live in a *ligisa* (Fig. 3).

Chiefly Behaviour

Koni refers also to a particular quality of chiefly behaviour known as *kautuwota*. This is the chief's accepted right to do anything in a superlative manner, and the superlativeness varies according to the rank of the person, so that from members of the Tabalu *dala* (who can do everything in the 'mostest' fashion) down the scale to people from those sub-clans who are barely distinguishable from commoners, this behaviour appears in varying degrees. The higher the rank of a person, the more positively, or loudly, or openly, is he able to do everything. This affects the way a person coughs, or clears his throat, or smokes a cigarette, or rattles his limestick in the lime gourd, or talks.

The form of the chiefly lime-gourd (*yaguma*) and lime spatula (*kena*), with customs and rituals relating to their use, would illustrate *kautuwota* in action but are perhaps too much of a diversion to chronicle here. These two items are discussed briefly below and are included in Appendix II.

In any form of behaviour in public the chief is expected to (or has the right to) be more self-assertive, better dressed, more finely adorned than any other person present. So in accordance with this principle, if at some public gathering of Kiriwinan people a chief of lower rank is wearing an ornament to which his rank normally entitles him, he would be reluctant to continue to wear it that day if it was more splendid than the ornaments worn by another chief of higher rank who happened to be present.

I would not like to convey the impression in this description that the chief is a self-assertive, loud-mouthed individual constantly displaying his own importance. He has the right to be but more often the reverse seems to be the case. A chief, especially one of high rank, usually carries with him a quality of quiet, settled dignity. He doesn't have to assert himself; he is already important and everyone knows it. But the right of *kautuwota* is the lot to which he is born and he has to exercise it on occasions. It is his *koni*, his prerogative, the burden of prominence that he must bear.

Yam Harvest Privileges

Koni privilege invokes certain specific privileges related to the annual yam crop. This includes the right to possess certain yams.[10] When these yams grow to the largest size, then no matter who has produced them they automatically belong to the chief. Such yams are kept by the chief in his council house and are usually kept there for display. Only on a very important occasion would they be given away and such a gift would indicate the approbation or generosity of the chief towards the recipient individual or occasion. This level of generosity would be recognised as the *kautuwota* principle in action.

The very best yams are called the 'feather of

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[8] On a recent visit I discovered a second equally splendid word describing the same thing: *kala mitakakanukula*, which derives from the verb *-kanekukwa*, 'to hang down loosely', and translates as 'his visible loosely hanging adornment'. This imparts a whole new cultural dimension to the term 'hang loose'! It seems that a Kiriwinan speaker sees no point in describing something with a simple short word if a polysyllabic alternative is available.

[9] The houses of *tokai* (commoners) do not, and cannot, have any ornamentation or painted decoration.

[10] Some of these were named *taitukesa, kuvibanena, kuvipiti, danuma, bugwa, mwedamwada.*

the village' (*kala dagula valu*, or *digulela valu*) and the very famous ones are kept for some years until they rot away from the stick to which they have been lashed. So while 'belonging' to the chief they are effectively a public display of that village's wealth and prestige.

In 1968 I saw one of these yams, a *kuvipiti*, on display in Omarakana, the village of the 'paramount chief', which I measured at 3.15 metres in length. This yam was not very heavy, being only 75 to 100 mm thick. Another yam dug the same year measured only 1.95 metres long but was very thick and branched (a *kuvibanena*) weighing approximately 50 kgs. The owners sought to present it to the Omarakana chief in payment of a long-standing obligation. However it had to be carried past another village, the chief of which believed himself entitled to possess it, and in the resulting fight one man was killed and some fifty other belligerents were detained at Her Majesty's pleasure for a specified period.

I have since seen another yam on display, described to me as the 'feather of the village', 3.45 metres in length. While inspecting and praising it I was regaled with stories of much bigger ones dug and displayed in previous years; the Kiriwinan, in common with the rest of mankind, loves a credulous auditor.

Two other yam-related privileges which are part of the chiefly *koni* may be mentioned here. One is the right a chief has to a certain chant being sung over his yams when they are being brought in from the gardens at harvest time. In the harvest month (*milamala*) there is a great deal of noise and fun, and the commoners' yams are brought in from the garden with a lot of noise and 'fun-nothing'[11] chants and songs. But the *sawila* chant is reserved for the chief's yams.

The second applies when a gift of yams, or an obligation payment yam, is being brought to the chief. On such an occasion, someone blowing a *tauya* (shell-trumpet) precedes the bearers announcing the action. The shell-trumpet is a common feature in many Melanesian societies. In Kiriwina, however, the *tauya* is reserved to announce actions related to the chief or public functions to which the chief has given his open support. For this reason it is included as part of chiefly *koni* in Appendix II.

Annual Tax and Other Privileges

An annual obligation called *pokala*, a form of tax or tribute, is paid to the chief. This is usually paid as a gift of ready-cooked fish.[12] When the people pay *pokala* to the chief in this way, he is obliged to make a return by feeding the people who have done so. This repayment may take place a few days after the tribute is given. I am not sure who wins, but as the winner is always the one who gives most away, the chances are that the chief, who must be well-practised in giving, would come out of this with the greatest prestige.

The chiefly sub-clans alone have the right (or is it the burden?) of contracting polygamous marriages, the number of wives you are entitled to varying with your rank. This practice, known as *vilayawa*, is not so strong today. When missionaries first went to Kiriwina in 1894, the then 'paramount' chief Enamakala, a powerful Tabalu of Omarakana village, had 40 or more wives. Today, chiefs having similar status may have about ten. In 1994 a Kiriwinan chief visited Canberra accompanied by his eleven spouses. (Sadly, I did not hear of it until afterwards.) The rights of respective ranks of chiefs in this regard are listed in Appendix III.

A further example of chiefly *koni* is known as *kavagina*. This custom involves ensuring that the chief's head is always higher than the heads of any others of lower rank. The lower-ranked person will stoop, or walk in a stooped position, when he passes or approaches a standing chief. If the chief is seated, then he must approach him crawling or shuffling very low. While this may not be observed so rigidly today, the practice of showing respect to people of importance by trying to keep the head low in approaching or talking with them is observed as a common every-day courtesy by Kiriwinan people.[13]

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[11] Neo-Melanesian Pidgin for 'nothing but fun' ie. no serious religious or political implications.

[12] For the Kavataria area, the fish is *mamila*. For inland areas, *kwau* (shark) is bought from the shark-fishing specialists in the northern villages and presented.

[13] A custom related to the practice of *kavagina* is called *vatala*, which is an early warning system used when a chief is travelling to another village. As he walks along, someone walks beside him and when they come to the outskirts of a village the chief's companion calls out, '*Guyauuuu!*'. By the time the chief enters the village, all are in respectful positions with their heads lower than that of the chief. Other customs relate to chiefly movement, such as someone blowing softly on a *tauya*, or a child walking before him carrying his *yaguma* on her head which would jingle as they walked, a surprisingly penetrating sound. All had the purpose of an early announcement of the chief's imminent entry.

Death Honours for a Chief

A final and fitting example of *koni* is the death honours paid to a chief or to any of the *gweguya*. Mourning customs due to a clan member are of course the lot of all but the *gweguya* are mourned longer. His widow or widows will wear some of his personal adornment. Special dirges are sung during the mourning period. In times past these laments (called *kavamwala*) were sung morning and night for several months after the death.

The mortuary exchange referred to above as *sigiligula* is often delayed for some years after the death of a high-ranking chief, as it is not every year that a yam harvest is large enough to do fitting honour to the deceased chief. As an example of this, one of the most powerful Tabalu chiefs, Mitakata, died in 1961, the year I first went to Kiriwina. When this paper was being first written in 1968, his mortuary *sigiligula* had not been held and his *bwaima* still stood in the village. Not until that mortuary distribution was held, several years after his death, could the yam house be ceremonially dismantled and destroyed, enabling the succeeding chief Vanoi to build his own *bwaima* and to assert the full glory of his chiefly standing.

The *koni* of a chief or of the *gweguya* has been sketched above. However, the rank of the various *dala* from high to low cannot be seen until the actual limits of privilege for each *dala* are defined. This ordering of the *koni* of each *dala*, as delineated by my colleagues Antonio and Tolosi, I have set out in Appendix III.

Chiefly Authority

I now take up the second distinctive feature of the *gweguya*, the authority or *karaiwaga* which is accorded them by Kiriwinan society.

The word *karaiwaga* in general use refers to the giving of orders, the wielding of authority, or the possession of special powers. It is a word with a very high functional load in Kiriwinan speech. In relation to a chief, *karaiwaga* refers to his area of authority, either the actual territory he rules over or the powers he exercises directly over the lives of his subjects.

Vested in the regnant chief

The right to exercise chiefly authority does not lie in the hands of all *gweguya* within a chiefly *dala*. Only those who actually hold office as chief of a village may be said to exercise chiefly *karaiwaga*. I have already noted that *koni* belongs in some measure to all the *gweguya*. But the dual possession of both *koni* and *karaiwaga* is the acknowledged right of the village chief only. This chief alone is addressed as *guyau*, and the total territorial area of his authority is referred to as *la guyau*, 'his area of chiefly power'.

Only one chief holds authority over a village as its *guyau*. Each village is traditionally the territory of one particular sub-clan of *gweguya* and if there is one of the right sub-clan chosen to govern that village then he will have the position of chief. If the particular families which hold the traditional right to supply a chief for one village die out, then other families from within the same *dala*, but of lower rank, would supply the chief. Rarely does another sub-clan take over the chiefly role for that village.

It has been pointed out that one *dala* does not occupy a cluster of villages so as to rule over a single area of territory. Rather, the chiefs of one particular sub-clan are chiefs for villages scattered over the whole area (Kiriwina Island and adjacent islands)[14] while other chiefs from different sub-clans rule villages between them. In any one village, when the highest-ranking man takes his position as *guyau*, other people of importance in that village and within the chief's own *dala* become members of a village advisory body known as *kaidadala valu* (see below).

Succession to chieftainship

The succession to chieftainship is necessarily someone chosen from within the chief's own *dala*. As the chief's wife (or wives) do not belong to the chief's *kumila*, the chief's own biological children are not in the line of succession. The line of succession for the new chief is through the present chief's sister's children. The eldest sister is the highest in rank,[15] so her sons will be

[14] See above, where Tabalu villages are named. See also the map in Appendix IV where the Tabalu villages are marked, showing that they are widely dispersed, with many other villages in between.

[15] Within each *dala* there are subdivisions descended from the six legendary female members of the first family. The eldest is termed the *vilitomoya*, the second *isakaili*, third and others *iluluwala*, and the youngest is *vilagwadi*. As membership of the *dala* is determined by matrilineal descent, the children of these six women are the *dala* originators. The children of the *vilitomoya* are of the highest rank but if all the female descendants were to die out, then the descendants of the next *dala* originator in line would be of the highest rank. The Tabalu chief in Omarakana in 1968 was a descendant of the original *vilitomoya* of the Tabalu *dala*. This means he was very powerful but the title of 'paramount chief' is a concept from outside Kiriwinan culture and does not really apply.

candidates. The choice of which son is completely in the hands of the regnant chief and not necessarily the eldest son would be chosen. A wise chief would be guided by the opinions of his advisory group, the *kaidadala valu*, but the final choice is his.

When the chief has chosen his successor, then the nephew chosen comes and lives in a house beside his uncle. He may live there for many years before the death of his uncle clears the way for him to become the new chief but by then he is known and accepted and has for many years watched his uncle and listened to the collective wisdom of the *kaidadala valu*.[16]

Consideration of the extent of the *karaiwaga* authority of a chief must include two levels; one is the traditional ancient *karaiwaga* which myth and tradition claim for that chief and the second is the actual power a chief will be expected to hold even by those who no longer believe in his ancient powers.

Traditional ancient authority

The *dala* are arranged in this section in a descending order of authority. The highest ranking *dala* is the Tabalu *dala*, both as to *koni* and *karaiwaga*. The authority of the old Tabalu chiefs literally had no limits, as informants frequently have told me. They controlled the rising and setting of the sun and movements of the moon and stars. The wind and tides, both foul and fair weather, rain and dry spells all occurred because of their knowledge and manipulation of their magic powers. Some sicknesses, and death itself, was ruled by them. If the annual yam harvest was excellent or if there was grievous famine, the Tabalu chief was at the back of it. Certain special forms of magic, such as *tokovasila* and *salokuva*, and the possession of certain stones having terrifying magic powers,[17] belong to the Tabalu.

Perhaps their most feared power of old was the communion they held with the dreaded *bogau* spirits and the death sorcery they worked through them.[18] This sorcery took various forms, culminating in the poisoning of the victim using either a slow-acting poison or one which killed the victim in a few hours.

Of all these ancient powers, probably only the last-named is still retained and that, for the most part, in secret. The others are today largely ceded to the Christians' God.

The second-highest *dala* was in times past the Sakapu (who bore the distinguished title of Toliwaga), a *dala* which is today almost extinct.[19] The Wabali *dala* is replacing them in this position of second in chiefly rank as to *karaiwaga*.[20]

Their special area of authority was in matters of war. If war was to be fought between the

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[16] I knew of one case where the chief changed his mind after the chief-elect had lived close by his uncle for many years. He considered his first choice had turned out to be *tonunumata* (stupid, lit. 'a person of dead mind'). So another nephew was established in the position and residence of honour. But when the old chief died, each of the nephews had a following and both claimed chiefly rank, so that considerable social unrest followed. The situation was never resolved and the split in chiefly authority has now been woven into the structure of chiefly power for that particular area. This demonstrates the flexibility of the system.

[17] I have been shown some of these and refused the viewing of one.

[18] If anyone had an enemy, or someone they considered blame-worthy on some count, they could go to a Tabalu chief and get his consent for the death of that person. Such an act was costly and had to be paid for with *veiguwa*, (wealth items). If the chief agreed, then he was responsible to see that the victim died (either by his act or by the act of one under his direction) and to choose the manner of death. In this and other sorcery killings, the chief held a position akin to that of a public executioner except that the deaths were effected secretly. The high level of respect and fear traditionally accorded the Tabalu comes in large measure from this.

[19] The Sakapu *dala* was the one which from long ago bore the title of Toliwaga (which means 'Captain or owner of the boat'). This was conferred upon them by the Tabalu for some unknown favour in the past; the right to use the title is highly treasured and is currently in dispute. There were two subdivisions within the sub-clan which were considered of sufficiently high rank to hold both the *koni* and *karaiwaga* which marked them as Toliwaga; one (Tomwalu) is now extinct and the other (Uweilasi) in 1968 had one surviving member, Tonuwabu of the village of Kaitagava. According to my colleagues he is the last person able to bear rightfully the title of Toliwaga. See also the following footnote.

[20] The Wabali *dala* will take the place of the Sakapu when the two ruling subdivisions noted in the previous footnote are completely extinct. They are in fact in the process of taking this position over for themselves. (The process by which such a transfer of powers and privileges within the class system takes place would make an interesting study and clarify some of the mechanisms by which flexibility is maintained to ensure good fit between the ideal and the reality of chiefly status.) The present position appears to be that they have assumed most of the *karaiwaga* and *koni* formerly held by the Sakapu *dala* but there remains one last step — to possess for themselves the honoured title of Toliwaga. Some of the Wabali chiefs have in fact already done this. Many Kiriwinans are angry at their presumption but the Wabali *dala* seem to be holding the title without any retaliatory action being taken. There are still sections of the Sakapu *dala* which have a certain amount of *koni* but have no acknowledged right to possess *karaiwaga*. These are descended from the *vilugugwadi* (younger female members) of the *dala*. It is in this context worth noting that in the late 1990s the Kwainama *dala* is attempting to increase its chiefly rank

traditional war zone territories of Kiriwina[21], or with an outside enemy, the decision as to whether the zone would engage in war lay with the Toliwaga. If he said 'War!' it was war; if he said, *Desi* ('Stop!') then they did not prepare for war. Also he had the power (the recognised authority) to stop a war which was in progress between two groups of Kiriwinan warriors. As a symbol of this authority he held in his hand an ebony club (*puluta*) or walking stave (*kaitukwa*); if he went into the middle of a battle in progress and thrust the club or stick into the ground, this was the signal for fighting to cease.[22]

That this authority is still in some measure recognised is illustrated by the story of Mitigilagela. In 1943 when Kiriwina was occupied by some 3000 Americans and a small Australian force, and all resident Europeans had been evacuated by compulsory orders, there was a temptation for Kiriwinan people to plunder what had been left behind by missionaries and traders. Then Mitigilagela, a Toliwaga chief from Kabwaku, walked several miles from his own village to Oyabia (the central mission station of the Methodist Mission) and plunged his ebony club into the ground in the middle of the mission station. All who saw and heard of this knew that there was to be no advantage taken by the absence of European mission leaders, that they were not at war with them. So while the head station of another mission, and properties of other European residents, were stripped and devastated by thieves, Oyabia was not touched. The reason why Mitigilagela did this is not known, as he had no known connection with the Methodist Mission and no reason to feel obliged to help it.[23]

From this it may be seen that the authority of the Toliwaga was not restricted to his own village area and was generally recognised in a war-related matter. Although the Toliwaga's *karaiwaga* has largely become irrelevant today, yet the Kiriwina people still recognise and obey him when he exercises his *karaiwaga* in its own proper sphere.

The third in *karaiwaga* rank was the Mlobwaima, which had the right to prevent war. The difference between the traditional authority of this *dala* and the Toliwaga seems to be that the Mlobwaima had the role of mediator or war-preventer but once the Toliwaga had pronounced for war, the Mlobwaima power was ended. He could not stop what had already started — only the Toliwaga could do this.[24]

Then comes the Kwainama *dala*, which had a small area of authority in relation to the distribution of the food (i.e. yams) which rightfully belonged to a chief, separating it from the yams of the *tokai* and deciding what shares were to be allotted to the various ranks of *gweguya*.

The ancient authority held by other lesser chiefs as distinct from that of the more powerful *gweguya* seems to be of little account. The chief of Omarakana village, Vanoi, a Tabalu of the highest possible rank, i.e. descended directly from the *vilitomoya* (eldest female member of the *dala*) declares that they are not in reality *gweguya* but merely *tokwaraiwaga* (men with authority). However, he looks down from a lofty eminence, scorning to recognise any powers they may have held; but other Kiriwinan informants from the lower ranks of *gweguya* do not support his viewpoint.

Some of these latter suggest that the Mwauli and the Osusupa *dala* held powers similar to the Mlobwaima but to a much lesser extent, while Tudava *dala* had certain powers relative to sorcery

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[21] The island of Kiriwina was traditionally divided into zones where each considered they had a particular loyalty in war. These zones are delineated in the map in Appendix IV.

[22] When he thrust the stick into the ground, the Toliwaga would say something like, *Lawai gai. Gala bigabu valu!* 'I have struck in the ebony; the village will not burn!' (in the case when warriors were preparing to burn the houses of an enemy village). When they met on the the traditional battle-ground of Duguveiyusa, between the villages of Omarakana and Kwaibwaga, he could secure cessation of the battle by laying a line of branches across the battle ground. Anyone from either side who crossed the line could be speared but if no-one crossed the line (called *kaligei*) then the battle was over.

[23] A Toliwaga had to be paid to perform his office. I did hear a rumour that a prominent church leader, Inose Ugwalubu, paid Mitigilagela in the traditional fashion with *veiguwa* and that he then went and performed his office. But I was never able to check this.

[24] Clearly there was much interplay between areas of *karaiwaga*. Due regard for Tabalu authority would have a place here as well. For only Tabalu could give the word that a person was to die and sometimes these deaths were effected within the melee of a traditional battle. Thus, there would have to be an understanding between Tabalu and Toliwaga regarding such a battle (which would prevent the Toliwaga from entertaining any Mlobwaima overtures) and the time of stopping a battle could depend on whether the Tabalu-sanctioned death had actually occurred. Thus the *karaiwaga* of a Toliwaga would have been in some measure subsidiary to the Tabalu in order to effect the death and the Mlobwaima *karaiwaga* would be in a position below that of the other two.

which made them an unpopular group with little real standing in the community.

The Kaitotu *dala* is said to have possessed no particular traditional ancient *karaiwaga* but only had *koni*. This was because the *dala* came long ago from Myuwa (Woodlark Island) where they had extensive powers; but when they migrated to Kiriwina their powers were not recognised. Instead they were given a limited amount of *koni* privilege so they do belong in the group of *gweguya* as I have defined them.

The other three *dala* (Kailai, Kulutula, Bwaitaitu) are on the lowest level having a little *koni* and no ancient *karaiwaga*.[25]

Tabalu supremacy

One thing that is clear from this study of ancient *karaiwaga* (as also is abundantly clear from the different levels of *koni* shown in Appendix III) is that the Tabalu *dala* is virtually in a class of its own above the *gweguya*, for both in ancient *karaiwaga* and in *koni* it is widely separated from all other *dala*. This was in fact what was asserted by Vanoi, who put the Tabalu (Fig. 6) at the top as the only real ruling class, named the Wabali (Toliwaga), Mlobwaima and Kwainama sub-clans as *gweguya*, and the other four as merely *tokwaraiwaga*.

But (on the other hand) it may be said that his viewpoint is both typical of and worthy of a powerful Tabalu chief who must of necessity exercise his right of *kautuwota*. The general mass of Kiriwinan opinion does not separate the Tabalu *dala* totally but is emphatically unanimous in supporting the fact of Tabalu supremacy. Such supremacy may not be easily seen by looking at the outward manifestations of their ruling authority; but people remember the glories of their past and still hold them in honour today through the *koni* that is accorded them and by their daily expectation that *kautuwota* will set them apart from all others.

Also (as one man told me quietly) everyone still fears the sorcery poisonings, which many believe still take place today; this fear will ensure the Tabalu of their supreme position for many years yet.[26]

Modern authority of chiefs

I now look at those ruling powers which mark the day-to-day *karaiwaga* of a village chief. For purposes of ordering the daily life of the village it may be said that all village chiefs have approximately the same range of authority but those who are considered to be higher on the chiefly scale of rank are more likely to be effective in their exercise of that daily *karaiwaga*.

The yam crop

The ownership and disposal of the staple yam crop is the real foundation and purpose of any effective chieftainship. For it is the chief's task and privilege to feed his people when necessary. Not that other members of the village community do not own food—they do; but the chief has great wealth in this regard, partly through his chiefly right to possess the best of certain yams and partly because of the annual yam harvests which must

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[25] These three *dala* were named to me almost as an afterthought by my colleague Tolosi, a man of the Tabalu *dala*. I found that one of the present *gweguya* of Kiriwina (i.e. someone having recognised chiefly authority over a village) was Guyau Lubatolu of Kudukwaikela, of the Bwaitaitu *dala*. It is clearly the case that if he can be recognised as *guyau* of that village then he is one of the *gweguya*. But his level of *karaiwaga* within the totality of *gweguya* is on the lowest level. There are *dala* below the Bwaitaitu which have some *koni* but which cannot have any *karaiwaga* and so cannot ever become the *guyau* of a village. I was also told that the *dala* who possess no *koni* at all are very few in number. These *dala* therefore rank as *tokai*, as the *gweguya* comprise those who possess some *koni* and have a potential share of ancient *karaiwaga*. The limited *koni* of these lesser *dala* is in being allowed to wear certain ornaments for dancing, provided that the *guyau* first gives permission, and provided that they are taken off immediately after the dance is concluded.

[26] A former Governor-General of Australia, Bill Hayden, actually made reference to the eating of poisoned food by the Trobriand Islanders, in a 1995 speech supporting euthanasia! His astonishing assertion was that the food was consumed knowingly, because the consumer has elected to die, having the desire to put an end to a useless old age in the interests of society! I can assure him that this is never the case. I have it on reliable authority that secrecy and duplicity surround the preparation of the poison (which may be eaten, drunk or smoked) so that the consumer partakes in innocence. But as soon as he has swallowed, he knows; and recipes for powerful and revolting emetics have been dictated to me. I am told he may survive if he can vomit within minutes of swallowing; but if not, he knows he is marked for death and usually succumbs rapidly. Also, the consumers are never the 'useless' aged, whose continued life is treasured by a family, but generally hale and hearty men who have overstepped some social boundary and are being made to bear the penalty. The act of administering poison in this way may be expeditiously dubbed as execution or assassination, or bluntly as murder.

by tradition be given each year to his wives by their brothers.[27]

This responsibility (and privilege) of feeding his people comes whenever the whole community is jointly engaged in a project of work, such as garden clearing, harvest, the building of major village structures, and at the time of *pokala* (tax).

A task may be initiated by the chief calling the workers together and reaching an agreement with them (*kabutu*) for some task. Then they will eat the chief's food[28] and afterwards go and work. While they work, the women cook more food supplied from the same source.

When the month of *Yavata* comes (about February), when food is scarcest (this season of scarcity is called *kuluvasaga*), the chief will take all the yams from his *bwaima* and share them out to the whole village.

When visitors from other villages come, as when *kula* trading canoes or canoes carrying clay pots for sale anchor off-shore, or when groups arrive on foot from neighbouring villages on some important visit, then it is the chief's task to feed them. This task of hospitality is nowadays shared by the village pastor, the village councillor and the chief, according to the nature of the business occasioning the visit.

The gardening cycle

The chief's decision is required in the gardening cycle—which land is to be cleared for gardening, the time of planting, weeding and harvesting, the gathering-in of the harvested yams to the village for display and storage, and any other communal decisions affecting yams. However such decisions would be made in consultation with his councillors (the *kaidadala valu*) and in particular with the *Towosi*[29] or garden magician (if the village has one).

The chief decides when the annual ceremony marking the conclusion of the harvest and the old year takes place. This Kiriwinan New Year celebration involves drumming the spirits of the dead out of the village (where, out of interest and with mischievous intent, they have been 'hanging round' throughout *yoba*, the harvest period!) so that they may return to their resting place, the island of Tuma, several miles west of Kiriwina Island. This ceremony may not be done every year but is one of the marks of a good harvest, when the spirits of the recently dead are expected to be part of the general rejoicing.[30] Everyone knows that if the spirits do not return to Tuma thoroughly satisfied with village affairs, some of them may be inclined to come back to their old homes, with uncomfortable and inconvenient results.

It falls to the chief to decide whether the harvest has been sufficiently good to justify a period being spent in dancing (*kaiwosi*). Such a period, which occurs during the month following harvest, gives opportunity for all who have any level of *koni* to display it; for at this time bodies will be painted and oiled, hair bedecked with feathers and ornaments, and whatever ornaments each is permitted to wear will be made ready. After a day spent in preparation, there will follow a night of drumming and dancing, the old men singing the legends which each dance celebrates. But the chief would only decide on a time of dancing if he considered it acceptable; in some years the transition from harvest to preparation of the new

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[27] The yams which are harvested by a household (man and wife) are the property not of that family but of the man's sister. His household will eat what is provided by his wife's brother. Thus it follows that a chief with (say) six wives will have six complete harvests to store and dispose of each year. If he has married wisely, the men who produce his yams will be the skilled gardeners (*tokwaibagula*) of Kiriwina. A great deal of personal status attaches to a recognised *tokwaibagula*; he is the generator of social and political power, power which becomes the *karaiwaga* wielded by the chief.

[28] The two words 'food' (*kaula*) and 'yams' (either *kuvi* or *taitu*) are used inter-changeably by Kiriwinans; and I find myself falling into the same pattern as I write! Whenever I use the word 'food', it must be understood that things like sweet potato, tapioca and cooking bananas are *not* referred to, as these are not regarded as 'true food' (*kaulotoula*) but as something to eat when there is no 'true food' available. Offhand I am not sure of the status of taro, for this is highly regarded; probably it falls into that other class of comestibles which includes pork, fish, crab and poultry, the things 'which season food' (*biwaki kaula*) and are used to mark very special occasions.

[29] The *Towosi*, who uses ancient magic spells at the inception of any community gardening activity, is a man greatly skilled in knowledge of the stars and the elements, especially in relation to the cycle of seasons. The magical side of the *Towosi*'s function is less in evidence today; he is more prominently an expert rather than a magician.

[30] This is a happy occasion when a special 'spirit food' made of mashed yams is baked in ground ovens, forming cakes the size of a large dinner plate. This food is laid out before food houses, and the village retires to rest, so the spirits can enjoy their feast. Then about 3 a.m. the entire village population rises and assembles on the Eastern boundary of the village and sweeps through the village towards its Western extremity, with yells, beating pots, drums, etc, driving the replete spirits before them towards Tuma. It has been pointed out to me that of course the spirits eat their food because by morning not a single scrap of the spirit food is to be found anywhere.

garden sites is so quick that there is no time for dancing.

All of the current authority noted above has some connection with the gardening cycle. Because they rely on the yam as staple, the Kiriwinans are bound to the annual cycle of clearing, planting, weeding, harvest and storage, and thus any person holding authority over this succession is inevitably their ruler, calling the tune for each day's activity.

Some today are prone to claim that the day of the chief is past and that the state of affairs described by Malinowski (e.g. in 'Coral Gardens and their Magic') no longer exists. This claim has no foundation in fact. Certainly many of the ancient powers are thought no longer to exist but the same was true in Malinowski's day, for many of the things he described were merely accounts of things Kiriwinan people said used to happen. These things aside, the chief's authority in the gardening cycle is little changed from eighty years ago, and his position and power as chief are still sure and firm.

The chief's lime gourd

The lime gourd used by a chief, together with its accompanying spatula, often becomes a symbol or tool of chiefly authority. When the chief walks from one village to another, the gourd is sometimes carried before him by an underling. If he wishes to make a public statement, he will remove the stopper and insert the spatula and, as both stopper and spatula are liberally decorated with *bwibwi* (see Appendix II), this causes a loud jingling sound. Rattling the spatula in the mouth of the gourd is a signal for talking to cease so the chief may speak. A chief on the move is seldom without his *yaguma* (gourd) and *kena* (spatula) (see Fig. 6). The chiefly lime gourd usually has no decorative patterns engraved on it.

Authority in other matters

Other matters are also the responsibility of the chief to decide, such as the decision where a house may be built in the village, arbitration in disputes over land or marriage relationships, some decisions regarding village participation in *kula* trading, and so on. There is also the exercise of his authority in protecting the *koni* rights of the *gweguya*. The chief generally, and a Tabalu chief particularly, is the guardian and 'policeman' over the rights of personal adornment and the decoration of houses.

Two examples of the exercise of this latter authority may be of interest. In the first, one of the *gweguya* was decorated for a dance wearing more of the *mmakata*[31] plumes (Fig. 7) in his hair than tradition entitled him to wear. This had the effect of a public statement that he considered himself of higher standing than the chief. I do not know to what extent the chief acted personally — usually they are men of a dignified mien who leave action to their subjects—but in the resulting tangle between two villages, after the Government constabulary had restored order, some sixty men were given prison sentences for 'riotous behaviour'.

In the second example, Vanoi, the Tabalu chief of Omarakana, told me that he was going to speak to the people of Tukwaokwa village to find out who had given permission for the local tourist hotel owned by a European to be decorated with the *kaibilabeta*[32] motif. 'I am not angry with the European,' he explained, 'he doesn't know any better. If the Tabalu chief of Tukwaokwa has done this or consented to it, it is all right, the symbol is his property. But if any of the lesser *gweguya* or the *tokai* have done this, then I will ask them, "Why did you do this?" And I will see that they pay a fine because to take *koni* which doesn't belong to you and give it to someone else is stealing.'

I need to note the existence and role of the village advisory group already referred to above. The chief rules his people with the assistance of a group of influential village men known as the council or *kaidadala valu*. Membership of this group is not restricted to *gweguya*, although all members of the *gweguya* living in that village seem to belong to it. Membership is determined by the possession of a *bwaima* (with yams stored in it), so that all members of the village who possess the food-wealth of the village have a say in the conduct of village affairs. The chief and the council meet in the village council house, the *buneyova* (Fig. 5). This building, as noted above, is the place where all the splendid 'feather of the village' yams are displayed and it may be decorated in addition with some of the chiefly house decorations listed in Appendix II.

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[31] See Appendices I and III for *mmakata* use and number permitted.

[32] See Appendix II for *kaibilabeta* decoration.

The Chiefly Hierarchy

I am now able to list the hierarchy of the chiefly *dala* of Kiriwina. They are first listed in their *kumila* in the order which my two Tabalu colleagues dictated. I then list the order of precedence which their level of *koni* indicates and the ranking they hold in respect of chiefly *karaiwaga*. The orderings are not mine but are those which my two colleagues say are correct.

Readers may check their analysis against the differing levels of *koni* and *karaiwaga* that are shown in this paper.

Ranks within the clans

Table 1 shows the ordering of chiefly *dala* within each *kumila*. As already noted, there is little that holds *kumila* members together, apart from possessing certain things in common.

Malinowski makes this clear (1932: 421) where he points out that 'in respect of rank, it is the sub-clan [the *dala*] rather than the clan that matters, and this holds good with regard to local rights and privileges . . . The clan is primarily a social category rather than a group . . . not of great importance . . . only to be seen at work in certain big ceremonies'.

The *kumila* also attains some significance because of the exogamous marriage custom, which means that a chiefly family must look beyond the chiefly families of its own clan for marriage alliances.

Chiefly rank in privilege and authority

One interesting fact that emerged from this study is that the chiefly *dala* are perceived as ranking in a different order depending on whether one is considering the privileges (*koni*) that Kiriwinan society accepts for each, or whether one takes into account the traditional (often archaic) areas of authority (*karaiwaga*).

In the case of privileges, the amount of *koni* which may be publicly displayed is often dependent on historic acts of 'grace and favour', where a *dala* of high rank has awarded one of low rank with some special privilege which thereafter elevates the recipient.

In the case of authority, however, there is little change, as modern authority is static and fairly uniform for all chiefly *dala*; thus traditional ancient authorities which do not change become the means of stating the position of a chiefly *dala* within the hierarchy.

TABLE 2. The ranking of chiefly *dala* according to *koni* and *karaiwaga*

Ranking	*Koni* (privilege)	*Karaiwaga* (authority)
1	Tabalu	Tabalu
2	Mlobwaima	Wabali
3	Mwauli	Mlobwaima
4	Kwainama	Kwainama
5	Osusupa	Mwauli
6	Wabali	Osusupa
7	Tudava	Tudava
8	Kaitotu	Kaitotu
9	Kailai	Kailai
10	Kulutula	Kulutula
11	Bwaitaitu	Bwaitaitu

Table 2 sets out the rank of chiefly *dala* which Tolosi and Antonio considered correct, showing the different order for privilege (*koni*) and for authority (*karaiwaga*). The differences in order may not seem great to the outside observer but to members of that society, where a feather wrongly worn or a yam given to the wrong person is able to spark a major riot and precipitate a death, these apparently small differences are of major significance. Re-ordering does occur and is in fact in progress for some *dala* right now but it takes place very publicly and is finally effected with full community awareness of the new privileges which one *dala* is now able to display without incurring the anger of other members of that society.

Concluding Comment

The rather annoying conclusion which must be stated is that there can be no conclusion as yet. For even though Kiriwinan society has been extensively studied, there is yet much that has not been researched which would be valuable for a better understanding of the chiefly hierarchy.[33]

[33] But see Powell (1960). This scholarly and well-researched paper does examine the economic forces at work in chiefly political activity but he explicitly leaves 'to other publications the full analysis of the main social institutions . . . namely those of rank and of kinship and marriage' (p. 118).

I am aware that in answering some questions I am begging others. If I had further opportunity for field study, I would want to do the following:

- examine the genealogical placing of all currently regnant chiefs within one *dala*;
- put the same questions to members of *dala* other than Tabalu;
- collect genealogies and lists of names peculiar to each *kumila*;
- investigate the migrations of recent (but prior to 1890) arrivals in Kiriwina;
- record each clan's origin stories and try to get a better understanding of clan structures;
- study the historical and contemporary politics of the Toliwaga;
- study recent Kwainama movements challenging Tabalu supremacy;
- do a detailed study of at least one *kaidadala valu*;
- identify the traditional chiefs who rule each village and map the pattern for each *dala*;
- investigate the possibility of the Tabalu *dala* being descendants of immigrants who came to dominate an earlier culture.

Much of this would have a bearing on the history of the rise of a class system which is, I believe, unique among the societies of Papua New Guinea. I find myself a little astonished that it is now almost 30 years since I first wrote this paper but still I am working on that language and studying that culture. If anything, the questions I would like answered increase with the years!

Appendices

Appendix I. Ornaments worn by the different class levels of the *gweguya*

(NB. 'A.' numbers refer to objects in the collections of the South Australian Museum)

bunodoga — a belt of *buna* shells (Fig. 8(A), A.8871).

bwibwi — small pieces of shell which jingle whenever an object or its wearer moves. They are attached as pendants to *soulava*, *saveva*, lime gourd stoppers, lime spatulas, etc. A high ranking chief would have many *bwibwi* as ornaments (see Fig. 6).

ikwalasi — a pair of *buna* shells worn suspended from one side of the *vivia*, at front, or from the waist-band of a *doba* (A.52469).

kaisapi — a bracelet of *buna* shells, worn on both wrists.

kala doga — in its simplest form (Fig. 8(D,E), A.8882, 8886), this ornament may be worn by the *tokai*. It consists of a boar's tusk which has grown into a circle (or the end cut off the large cone shell used in making a *mwali*, which has the same appearance), worn suspended from the neck by a string. When used by a chief the string is replaced by a small *soulava*, with the end tied behind his head, terminating in a *buna* shell. Clusters of *bwibwi* are added. A small *katudababila* may be used in place of the string or the beads.

katudababila — a belt of *kaloumwa* discs, worn with or without the *bunodoga*. The number of lines of discs indicate the rank of the wearer, the maximum being five as worn by the Tabalu. A small *katudababila* or fragment of the same may be worn as part of a *kala doga* (q.v.) (Fig. 8(B), A.58657).

kwasi — a woven arm-band made from a fern fibre (*kusikwasi, kasuma, degila*). There are three different forms:

a) simplest, worn as a wide armband on each upper arm and known as *kwasi kaewa* (A.61997, 62000).

b) *mlipwapwa* worn on the upper arm, between the *kwasi kaewa* and the elbow, by all regardless of class.

c) *kwasi tilawa* or *mtuwetuwa,* worn on the forearm by *gweguya* only, of greater width for higher ranks (Fig. 10, A.74493, 74494).

An addition to the *kwasi* is the placement of scented leaves for important occasions, while some may add long streamers of *wowona* (pandanus); these are called *bisila* and indicate that there is some particular reason for rejoicing, or some project of considerable importance in progress

lubakaidoga — a pair of *buna* shells worn on the leg just below the knee (A.66709).

lùluboda – an anklet of *buna* shells worn on both legs; pairs of *buna* shells (known in this use as *puluweiwa*) are sometimes suspended from this ornament.

mmakata — a long plume made up of two or three long feathers joined end to end, decorated along the side with the red breast feathers of the *karaga* parrot; worn in the hair for dancing.

midimidi — small woven leaf streamers (see *kwasi*) tied to the wrists for dancing.

saisai — *buna* shells tied to the hair at the back of the head (A.52469).

saveva — a headband consisting of a (usually) single line of *kaloumwa* discs worn across the forehead (Fig. 6; Fig. 8(C), A.8875). Higher ranks wear this with the addition of pairs of *buna* shells suspended from it. The pairs of shells are called *bunavigula*.

segadulu — a *soulava* 'necklace' terminating in a large *buna* shell or pearl-shell crescent, with *bwibwi* made of scraps of pearlshell, etc (A. 55332). This is worn suspended from the back of the head, letting the beads hang down behind usually to about the buttocks, longer for higher ranks.

soulava — a necklace of *kaloumwa* discs (A.17925). The length varies considerably, from 40cm to 150cm, and may be single or double; the longest are worn crossed across the breast and are called *tabala*.

tabala — a long *soulava* worn crossed (see Fig. 6).

Appendix II. Houses, house decorations and other objects used by *gweguya*

(NB. 'A.' numbers refer to objects in the collections of the South Australian Museum)

Houses:

buneyova — the council house of the chief, where he meets with his *kaidadala valu*. The *buneyova* usually has a raised platform where the chief sits elevated above others for due observance of *kavagina*. In the *buneyova* are hung the best long yams on display; fifteen or twenty may hang there at harvest time, and the number dwindles as obligation payments are made, leaving only the one or two *kala dagula valu* which are never given away.

bwaima — the yam storehouse, built near the *ligisa* and decorated in manner similar to it. It is always the biggest yam storehouse in the village and is placed in a prominent position for the public exhibition of the annual yam crop.

ligisa — the chief's sleeping house (see Figs 3, 9), erected in highest point of the village, often elaborately decorated with items listed below; walls made of *niniva* (sago palm walling), the use of which is reserved for chiefly dwellings.

House decorations:

gola — small carvings (of birds, bats, crocodiles, etc) and decorated discs (eg. A.9728) mounted on the *salala* sticks (see below).

kaduguwai — a pole projecting from the ridge pole of the *ligisa* at the apex of the decorated gable (also on the *bwaima* and *buneyova*); it may be 2 to 3 metres long, decorated with clusters of crescent-shaped coconut husks lashed at several points along the pole. Each cluster of six or seven husk segments is called a *kovisalu*. Each house so decorated may have eight or nine *kaduguwai* projecting from each end of the ridge pole (see Fig. 3).

kaibilabeta — a carved house board which is the base of the triangle formed by gable boards.

kaisikalu — another house board which is placed vertically in the centre of the gable, the base resting on the *kaibilabeta*.

kaivalapula — the two gable boards (carved and painted), the usual motif being the *udowala* (a bird).

kapiwa — a rope decorated at several intervals with *buna* shells which hangs from the gable peak or the *kaduguwai* pole of the *ligisa*, terminating in a cluster of several *buna* shells. The length varies with the rank of the resident chief, those belonging to the Tabalu chief almost touching the ground.

laba — a smaller version of *kaibilabeta* used on the gable of the *bwaima* (yam storehouse — see Fig. 4); a difference in the gable construction is that no *niniva* (sago palm walling) is used in the centre of the gable construction.

salala — spiked sticks projecting a metre or so from the roof down each side of the gable of the *ligisa* (see Fig. 3); *gola* (see above) are sometimes mounted on them.

tataba — a portable houseboard suspended usually under the *kaibilabeta*, carved and decorated with motifs similar to the *kaibilabeta* (A.55309; see also Fig. 4 where the chief's *tataba*, complete with shells, is hung). Under the *tataba* hang three or four rows of *buna* shells (about 30 shells in each row). The number of rows gives some indication of the owner's rank. When a chief dies, the *tataba* complete with *buna* shells will decorate his grave for some years. The chief may give his support to some public event by loaning his *tataba*, which would be hung on public display.

Other chiefly items:

kaitukwa — the ebony stave used by the Toliwaga

as a symbol of his authority; an ebony club (*puluta*) also could be used for this.

kena — the lime spatula, which for a chief is large and fine, usually made of bone (eg. A.19699), and extensively decorated as noted for the *yaguma*, the addition of many *bwibwi* giving audible prominence to every flourish of the chiefly lime spatula. In times past the bone used was that of a deceased relative (a leg or arm bone). The rattling of the *kena* in the mouth of the *yaguma*, which for all others is done in a subdued or gentle way, is for the chief a statement of his authority, being done in a pronounced fashion in accordance with *kautuwota*, and being used to call for silence or to announce his intention to speak to the village (see Fig. 6, where chief Pulitala holds his *kena* in his right hand).

tauya — the shell trumpet, the use of which is reserved for chiefly concerns, or used only with chiefly permission.

yaguma — the lime gourd (e.g. A.19700) used in the social process of betel-nut chewing (*kaui*); while everyone has his lime gourd, that used by the chief is much larger, elaborately embellished with many *bwibwi* (hanging decorations), with a *doga* (pig's tusk) stopper much larger than others, and frequently a rope for wearing it suspended from the shoulder or with a special basket for carrying (see Fig. 6).

Appendix III. Hierarchy in *koni*

See pages 108–109.

Appendix IV. War zones

The island of Kiriwina was in former times divided into areas each of which was unified by common loyalty in times of war. On occasions, two or three zones would make an alliance and so fight another group or groups. The political loyalty that this implies is still recognised today although the highly formalised acts of war no longer take place.

The Northern section of Kiriwina Island shown on the map (Fig. 11) was divided into five zones which had a collective loyalty in war. These five groups fought or raided one another but did not go out to the nearby islands of the Trobriands, nor did they go to the part of Kiriwina Island south of Kwabula. These zones are as follows:

North-west section	Wakaisa
North-east section	Kulakaiwa
Central section	Katumatala
South-west section	Kuboma
South-east section	Luba

Traditionally, Katumatala and Kuboma were called in by Wakaisa to fight Kulakaiwa, or by Kulakaiwa to fight Wakaisa. Their services were bought with *veiguwa*. If Kulakaiwa was successful in buying their services, these two hired areas would congregate at Obwelia or Okaikoda to eat (the custom of *kabutu*), and then prepare for battle. They would paint their bodies (*biputumasi*), decorate their hair with feathers (*bikalaisi*) and work up a battle fervour by certain dances (*biseiwausi*) before going to the battle-ground. If Wakaisa was the successful bidder in hiring their services, they would congregate at Yalaka for the same meal and battle preparation.

War took two forms. The warriors would go to a village or succession of villages, burning the houses, killing pigs and destroying food gardens. Or else they would assemble to fight an opposing force of warriors at the traditional battle-ground Duguveiyusa (close to Omarakana village).[34] If the latter form was chosen, all the women went along to watch. Such battles were highly formalised and deaths were generally those which the Tabalu chief had decided would take place.

It is recorded of one such battle that when all the warriors were drawn up ready to begin, it was found that the sun shone into the eyes of one side, giving their opponents an unfair advantage; so the disposition of both sides was re-arranged to even things up, after which battle was joined. Some of these battles are described in detail in Seligman 1910: 663-668.

Villages that are traditionally ruled by Tabalu *dala* chiefs are noted in the map (Fig.11) by suffixing (T) to the village name.

Appendix V. Chiefly terms used in Bible translation

Translation is never a mere substitution of words which 'mean the same'. The cultural context of any word used in a translation is all-important if a translator wishes his readers to enter into the same understanding of a translated text as the original hearers had.

Thus words from or related to the chiefly

[34] This area is still used today for competitive cricket matches!

Appendix III. Hierarchy in *koni*

Koni (privileges)	TABALU	MLOBWAIMA	OSUSUPA	MWAULI	KWAINAMA
saveva	+	+	+	+	+
saveva with ***bwibwi***	+	-	—	-	-
mmakata (no.)	10 or 11	4	1 or 2	2	3 or 4
tabala	+	-	-	-	-
luluboda	+	+	+	+	+
luluboda with ***puluweiwa*** (no.)	8	4	-	-	-
katudababila (men; no. of rows)	5	4 or 3	4 or 3	4 or 3	4 or 3
lubakaidoga	+	+	+	+	+
segadulu	+	+	+	+	+
	3 or 4, long	2, short	short	short	short
kaisapi	+	+	+	+	+
mtuwetuwa	+	+	+	+	+
	wide	narrow	narrow	narrow	narrow
ikwalasi	+	+	-	-	-
	women only	men & women			
saisai	+	+	+	+	+
bunodoga (if ***katudababila*** not worn)	+	+	+	+	+
bunodoga (women with ***puluweiwa***)	+	+	-	-	-
vilayawa (no. of wives)	many	3 or 2	1	1	2 if women agree
kaibilabeta	+	+	+	+	+
laba but no ***niniva***		-	-	-	-
kaisikalu	+	-	-	-	-
kaivalapula	+	+	+	+	+
tataba (no. of rows of ***buna***)	many	5 to 3	3	3	3
kapiwa	+	+	+	+	+
	long				
kaduguwai	+	+	+	+	+
gola & salala	-	-	-	-	-
youlala	+	+	+	+	+
			little	little	

WABALI	TUDAVA	KAITOTU	KAILAI	KULUTULA	BWAITAITU	TOKAI
+	-	+	+	+	+	-
-	-	-	-	-	-	-
10 or 11[1]	1 or 2	1 or 2	1 or 2	1 or 2	1 or 2	-
-	-	-	-	-	-	-
+	-	-	-	-	-	-
-	-	-	-	-	-	-
4 or 3	4 or 3	3 (low)	3 (low)	3 (low)	3 (low)	2 or 1 (low)
+	+	+	+	+	+	-
short	+ short	-	+ short	+ short	+ short	-
-	+	-	-	-	-	-
+ narrow	+ narrow	+ narrow	+ narrow	+ narrow	+ narrow	-
-	-	-	-	-	-	-
+	-	+	-	-	-	-
+	+	+	+	+	+	Some *dala*
-	-	-	-	-	-	-
5 or 4	2 if women agree	1	1	1	1	1
-	+	-	-	-	-	-
-	+	-	-	+	+	-
-	-	-	-	-	-	-
+ (no paint)	+	-	-	-	-	-
3	3	-	-	-	-	-
+	+	+	-	-	-	-
+	+	+	-	-	-	-
+	-	-	+	+	-	-
+	+	+ little	+ little	+ little	+ little	-

[1] This is a special favour accorded the Wabali by the Tabalu because long ago the Wabali rendered them a service and this *koni* is their payment. It is called *kulututu paila mapula tomota* (*Kulututu* for the price (answer) of a person) but no one today remembers why, or what the service was.

hierarchy of Kiriwinan culture have a necessary place in translation of hierarchical concepts, but they must be used with care lest the full local equivalence of a term enters into and distorts the translation of what is essentially a foreign culture concept.

As an example, the island Tuma (to which the spirits of dead Kiriwinans go) could be seen as an excellent translation for Hades or similar words used in the Bible for the shadowy abode of departed spirits. But Kiriwinans believe that it is only their spirits which abide there. They know, for instance, that the Dobu people's spirits go to a mountain near Dobu called Bwebweso. So using Tuma as a substitution for Hades, implying that the spirits of the prophet Samuel and King Saul are mixing with those of Kiriwinan chiefs of renown, would not be appropriate. However the presence and understanding of Tuma is too valuable to be cast aside. So it may be used to elucidate a transliteration of Hades (*Edesi*) by adding a reference like *Baisa mina Yudia idokaisi Tuma, si valu tomata.* 'This is what the Jews call their place Tuma, the village of the dead' (as was done in Luke 16.23). Or on occasions it is entirely appropriate to substitute Tuma for Sheol (an equivalent for Hades), as in Psalm 6.5 'In the world of the dead you are not remembered' (*gala availa biluluwaim metoya mapilana Tuma*).

I comment here on some words from within the lexicon of the Kiriwinan chiefly hierarchy, which I have used in Bible translation.

First, use of the word *guyau*. This has been taken to be a superlative title of overlordship, and so has been used for some translations of the Greek term *Kurios* — for the divine name, 'Lord' and for the title given to Jesus after his resurrection. It is also used where rank is indicated, as in Matthew 9.34, *si guyau baloma gaga,* 'the chief of the evil spirits'. We have had to be careful over its use at other times, where it was used as a means of respectful address, on occasions to Jesus or to the disciples, and to some others. For these occasions we have used another title of respectful address which is used for anyone regardless of rank or nationality (*tomoya,* 'old man'; or *toboma,* 'distinguished one'). Another of the uses of *guyau*, as a reference to the area in which a chief's authority applied, was entirely correct in John 18.36, *ulo guyau gala metoya ovalu watanawa* 'my authority (kingdom) is not from this world'.

The Greek term *doxa,* 'glory' (with similar Hebrew equivalents as *kabod*) has been in part served by chiefly terms describing the greater decoration of the chief's person, his superior *koni.* When in reference to any earthly glory, as in Matthew 4.8, 'kingdoms in all their greatness', or the richly adorned Temple in Luke 21.5, the term *kala katububula* 'his (its) adornment' is adequate. But when 'Solomon arrayed in all his glory' (Matthew 6.29) is translated, the term which is applied to a chief when he is wearing his full extent of *koni* is precise and accurate, *kala kalugologusa.* In fact this is an instance in which the highly specific Kiriwinan term is a more accurate statement of the meaning and intention of Jesus's word than the comparatively weak Greek original!

The chief's house, *ligisa*, sometimes spectacular in its decoration, is forbidden to all but the chief himself. It is the highest structure in the village, with its floor frequently on a level with the ridge-poles of other houses, most of which are built on the ground. Only the chief is allowed to enter it and anyone daring to break the prohibition would be marked for death. Thus we have used *ligisa* for the Holy of Holies within the Jewish Temple, which the High Priest alone may enter and at that only once a year.

The chief's council-house, *buneyova*, has been used to translate God's judgment seat, for it is in the *buneyova* that the chief makes his decisions; and if he is involved in settling disputes amongst his people or deciding village matters, then from the *buneyova* and in the hearing of all he makes his pronouncements. Thus *buneyova* conveys to the people the idea of a place where the rights and wrongs of a case are considered and decided on. It was also used in Matthew 26.3 to define the place where the chief priests and elders met and decided to have Jesus killed.

The annual tax, *pokala*, due to a chief comes into obvious use for temple tax, taxes due to Rome, etc. The only thing against it is that the Roman authorities, unlike Kiriwinan chiefs, did not do the grand thing and immediately respond with a feast!

The physical act of reverence given to a chief, *kavagina*, while not so pronounced now as in old times,[35] is very strongly imprinted on Kiriwinan people's daily behaviour in the way they show respect. This affects cross-cultural behaviour

[35] See, for instance, Monckton 1921:91, where the traditional *kavagina* accorded Guyau Enamakala is described; *kavagina* today is not practised to the level Monckton describes.

patterns which are often mis-interpreted. Thus to stand alert before a seated person in authority, which a European may consider both polite and proper, a Kiriwinan would interpret as belligerent and rude. He would immediately sit, an action the European may see as a careless act in defiance of authority! For biblical reference to a physical posture adopted in honour of someone, *kavagina* is accurately used in many instances where the translation of actual words would be misleading. When the leper 'falls down before' Jesus, or in expressions like 'threw himself down' before Jesus or 'fell on his knees before the king', their literal translation would convey the message of some accidental fall or movement not involving reverence; whereas *ikavagina omatala* 'he reverence-stooped before him' shows clearly the bodily posture and the purpose of it. He is approaching the chiefly figure in an attitude of reverence and with the intent of petitioning or thanking. Degrees of reverence may also be defined by describing how low the stooping act is, which adds to the precision of translation in some cases (e.g. 2 Samuel 1.2, 'He bowed to the ground in respect').

The word *karaiwaga* comes into translation a lot, as it bears a high functional load in the language and can be used in many contexts denoting Jewish Law, giving orders, authoritarian acts, etc. Because of its role in describing chiefly authority, it has had ready application to the New Testament concept conveyed by the Greek *basileia theou,* 'Kingdom of God'. It may be even more specific, more accurate, in describing the nature of that concept than the English translation which brings to mind a territorial rather than an authority area of rule.

The chiefly practice of agreeing on consultation with his people and sealing the agreement with a meal, known as *kabutu*, is the best equivalent yet found for 'covenant'. When the chief and people *kabutu* for some work, it means that the people have agreed to do what the chief asks and he in turn agrees to provide for them while they do that work. Thus this word has become the term used for 'Old Testament' and 'New Testament' (*Kabutubogwa, Kabutuvau*), the terms describing those books which tell of God's relationship with his people.

The term *koni* has the dual reference either to a physical load anyone may carry, or to the special prerogatives of chiefly rank (recalling the old and rather unfortunate term, 'white man's burden'). While generally used for burdens borne, it is rightly used in Luke 22.29, *isakaigu ulo koni bayosi karaiwaga, tuvaila makawala asakaimi mi koni bukuyosisi mi karaiwaga* ('he has given me the right to rule, so I will give you the same right'). Also in John 1.12, *si koni matausina (bimila litula Yaubada)* correctly translates 'their right (to become children of God). Thus the text may refer to special privileges and rights which others recognise as belonging to some, the possession of which becomes an obligation to their use in the correct way.

Many other words listed above could be shown as appearing in translation but I think those listed here are the major ones in which an understanding of their role within the chiefly hierarchy has enabled translators to make a proper and highly specific use of them.

Some words have been carefully excluded. For example, *Tabalu* (to describe rulers of high rank) has not been used, lest it should seem that the Bible gave specific commendation of one social group in Kiriwina!

Also the term *kautuwota*, which describes the chief as being the 'mostest' in any field, or the loudest in any situation, should have a proper place somewhere. But to date I have not been able to bring it to bear on any passage; either to describe supremacy in God (which may well be good) or to show loud-mouthed bragging or harsh authority (which could be dangerous).

Appendix VI. Lexicon of words used in this study

bagula	food garden
baloma	spirit
bisila	a pandanus
bogau	dangerous spirit
bomileilai	house decoration
bubuna	dove
bugwa	species of yam
buna	eggshell cowrie
buneyova	council house
bunodoga	shell belt
bunukwa	pig
bwaima	yam storehouse
bwala	house
bwibwi	a decoration
dagula	feather
dala	matrilineal sub-clan
danuma	species of yam
degila	a weaving string
desi	stop
digulela	its feather
doga	tusk

gabu	to burn
gai	ebony
gala	no, not
gegila	a parrot
gola	carved ornament
gugwadi	children
guyau	chief
gwadi	child
gweguya	chiefs
ikwalasi	shell cluster
iluluwala	next in line
isakaili	second in line
kabutu	agreement
kaduguwai	house pole
kaibilabeta	a houseboard
kaidadala	council
kailavasi	goanna
kaimelu	a death custom
kaisapi	shell bracelet
kaisikalu	a houseboard
kaitukwa	walking stave
kaivalapula	gable boards
kaiwosi	dancing
kala	his, her, its
kaligei	boundary
kaloumwa	a red shell
kalugologusa	chiefly splendour
kanekukwa	to hang down
kapiwa	spider web
karaga	a parrot
karaiwaga	authority
kasuma	a weaving string
katububula	adornment
katudababila	shell belt
kaukwa	dog
kaula	food
kaulotoula	true food
kautuwota	act chiefly
kavagina	act of reverence
kavamwala	a dirge
keiyuna	snake
kena	lime spatula
koni	burden, privilege
kovisala	house ornament
kula	wealth trading
kulututu	mortuary payment
kuluvasaga	scarcity
kumila	clan
kusikwasi	a weaving string
kuvi	yam family
kuvibanena	large yam
kuvipiti	long yam
kwasi	woven armband
kwasikaewa	wide armband
kwasitilawa	chief's armband
kwau	shark
la	his, her, its
laba	a houseboard
ligisa	chief's house
liliu	legend
lubakaidoga	shell cluster
lulubodа	shell anklet
mamila	a fish
midimidi	flag
milamala	harvest month
mina	people of
mitakaka-nukula	chiefly splendour
mlipwapwa	narrow armband
mluveka	eagle
mmakata	feather plume
mtuwetuwa	chief's armband
mwali	wealth armband
mwedamwada	type of yam
niniva	sago leaf walling
paila	for
pokala	tax
puluta	club
puluweiwa	shell cluster
sagali	a distribution
saisai	shell cluster
salala	house ornament
salokuva	type of magic
saveva	a headband
sawila	a chant
segadulu	a necklace
sigiligula	a death custom
soulava	wealth necklace
tabala	a necklace
taitu	the staple yam
taitukesa	type of yam
tataba	a houseboard
tauya	shell trumpet
tokai	commoner class
tokovasila	type of magic
tokwaibagula	expert gardener
tokwaraiwaga	an authority
tolela	a man of
toliwaga	captain of boat
tomoya	old man
tonunumata	stupid person
towosi	garden magician
udowala	a bird
valu	village, place

vatala	respect
veiguwa	wealth items
vila	a woman of
vilagwadi	youngest female
vilayawa	many wives
vilitomoya	eldest female
waga	canoe
wai	to strike
waki	to season (food)
wowona	streamers
yaguma	lime pot
yavata	month of dearth
yawali	a death custom
yoba	harvest time
youlala	painting on houses

FIGURE 1. Antonio Lubisa Bunaimata with a chief's lime gourd (Note: chief's lime gourds are usually plain, lacking the curvilinear designs of this one) (Photo: R. Lawton, 1968).

FIGURE 2. Young man of Tukwaokwa village wearing his father's chiefly wealth (Photo: D. Lawton, 1994).

FIGURE 3. Chief's house (*ligisa*). Note gable boards (*kaivalapula*) and *tataba* with pendant *buna* shells; the *kaduguwai* project from the peak of the gables (Photo: R. Lawton, 1972).

FIGURE 4. Chief of Kavataria village in front of his yam storehouse (*bwaima*) (Photo: R. Lawton, 1991).

FIGURE 5. A chief's council house (*buneyova*) at Omarakana displaying the long yams (*kala dagula valu*) lashed between two poles (Photo: R. Lawton, 1972).

FIGURE 6. Pulitala, a Tabalu chief, holding his lime gourd and spatula (Photo: R. Lawton, 1972).

FIGURE 7. Dancers wearing *mmakata* plumes which stand above their white cockatoo feather head-dresses (Photo: R. Lawton, 1972).

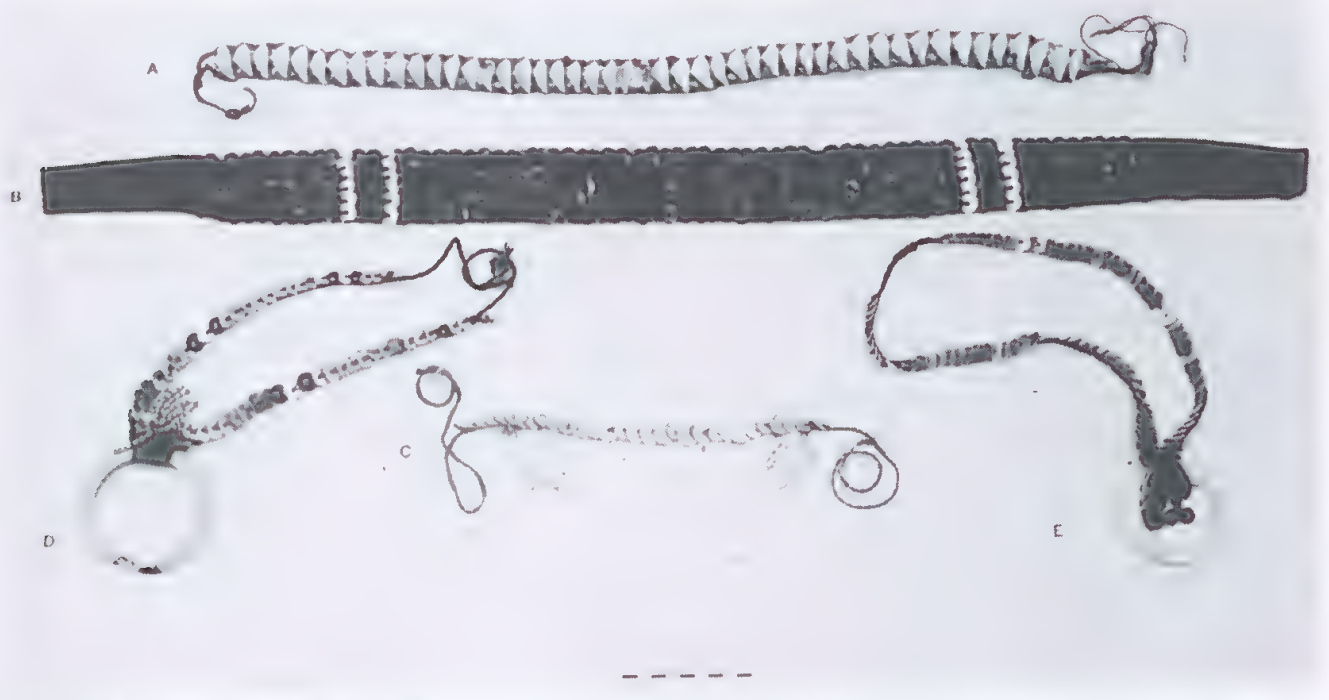

FIGURE 8. Chiefly ornaments in the South Australian Museum collections (Photo: Elizabeth Murphy, Artlab). **A.** A belt of small *buna* shells (*bunodoga*) A.8871. **B.** A belt of *kaloumwa* shell discs (*katudababila*) A.58657. **C.** A headband of *kaloumwa* shell discs with pendant *buna* shells (*saveva*) A.8875. **D.** A necklace of *kaloumwa* shell discs with pair of pig tusks attached (*kala doga*) A.8882. **E.** A necklace of *kaloumwa* shell discs with shell ring attached (*kala doga*) A:8886.

FIGURE 9. Gable of chief's house (*ligisa*) at Omarakana. Note gable boards (*kaivalapula*) on either side, central vertical gable board (*kaisikalu*), the *kaibilabeta* at the base of the gable and the *tataba* with three rows of *buna* shells below that (Photo: R. Lawton, 1972).

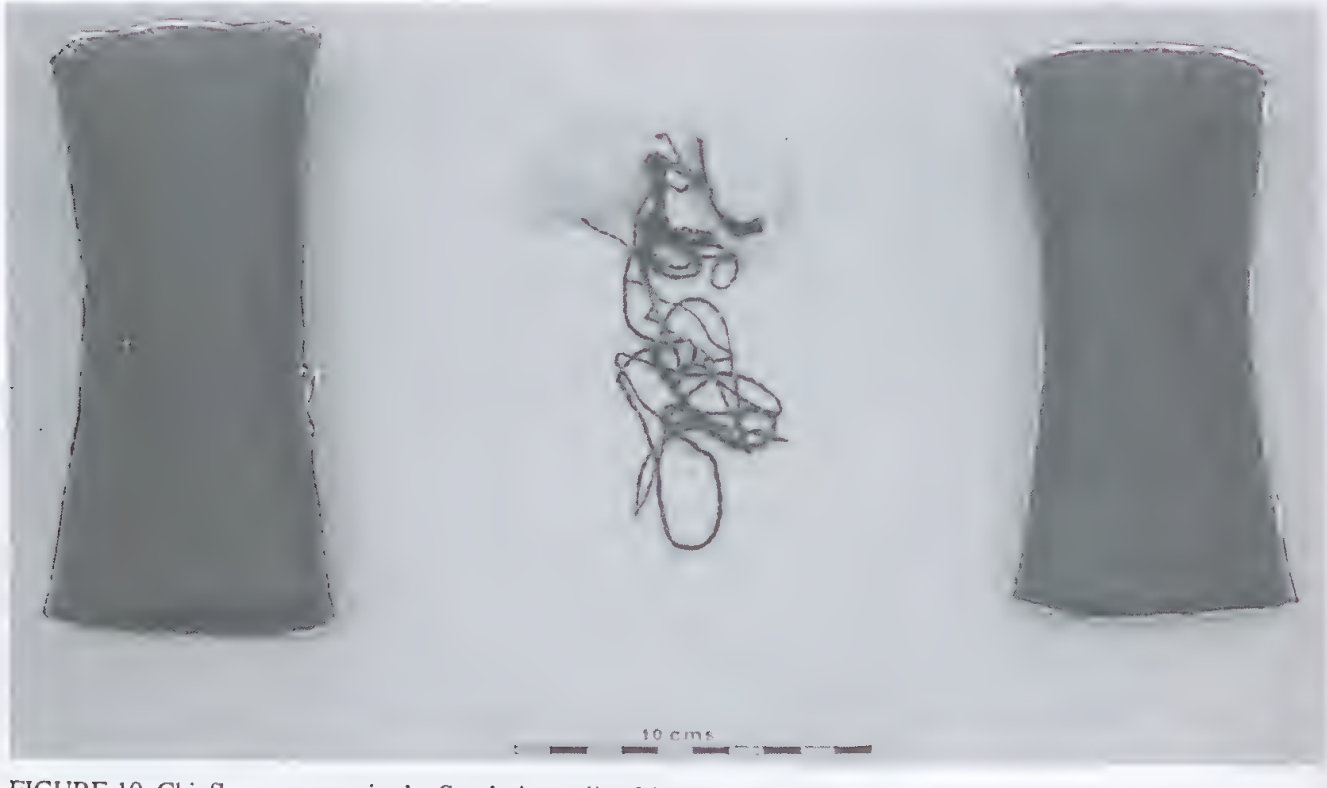

FIGURE 10. Chiefly ornaments in the South Australian Museum collections. A pair of woven armbands (*mtuwetuwa*) (A.74493, -4) and head ornament (*saisai*) of *buna* shells (A.52469) (Photo: Elizabeth Murphy, Artlab).

FIGURE 11. Map of the northern part of Kiriwina, showing the five war zones.

Acknowledgments

Especial thanks to my wife Margaret for editing this paper and casting it into its present form.

References

Note: This paper is a study of the Kiriwina chiefly hierarchy as viewed by two high-ranking Tabalu in 1967. For this reason I merely glanced at the literature and so the references are few. The reader is referred to the excellent bibliography in Weiner 1976: 261–273 which *inter alia* includes the major references in other works to the Kiriwinan chiefly order. There are undoubtedly more recent references of which I am unaware.

MALINOWSKI, B. 1922. 'Argonauts of the Western Pacific'. London: Routledge & Kegan Paul.

— 1932. 'The Sexual Life of Savages'. (3rd Ed.) London: Routledge & Kegan Paul.

— 1935. 'Coral Gardens and Their Magic'. (Vol.1) London: Allen & Unwin.

MONCKTON, C. A. W. 1921. 'Some Experiences of a New Guinea Resident Magistrate'. London: John Lane, The Bodley Head.

POWELL, H. A. 1960. Competitive Leadership in Trobriand Political Organisation. *Journal of the Royal Anthropological Institute* **90**:118–148.

SELIGMANN, C. G. 1910. 'The Melanesians of British New Guinea'. Cambridge: Cambridge University Press.

WEINER, A. 1976. 'Women of Value, Men of Renown: New Perspectives in Trobriand Exchange'. Austin: University of Texas Press.

REDISCOVERY OF *ENOCHRUS PEREGRINUS* IN AUSTRALIA (COLEOPTERA, HYDROPHILIDAE)

In a recent paper (Watts 1998) I cast strong doubts on the record of *Enochrus peregrinus* Knisch, 1922 from Australia. This record was based on a single collection of three specimens from Sydney prior to 1921 only one of which survives. It has not been collected since. In addition, *E. peregrinus* belongs in the subgenus *Enochrus* (Watts 1998) which is otherwise known only from the Holarctic region. I report here the recent collection of two additional specimens. One specimen is a male which allows the description of the male genitalia for the first time.

The specimens were both collected from a small shallow drainage ditch in an area of peaty soil three kilometres north of Bulli in New South Wales, the first on 2/11/1997 and the second on 27/11/1998. This locality is some 50 kilometres south of Sydney, the only previously known locality. The specimens are now in the collection of the South Australian Museum.

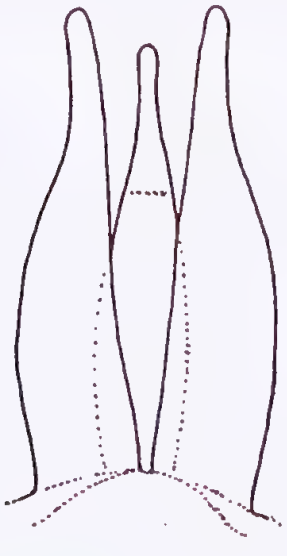

FIGURE 1. Dorsal view of apical portion of male genitalia of *E. peregrinus*.

The dorsal surface of the specimens is as previously described. Ventral surface (which has not been previously described): dark testaceous to black with appendages slightly lighter; evenly and quite strongly rugose/punctate, covered with short fine setae including the femora; mesosternal keel narrow, well developed, sharply triangular in side view, with a low, sharp ridge extending backwards between the mesocoxae.

Male: central lobe of aedeagus relatively thin, bluntly pointed, apical pad weak, collar closer to tip than to base; parameres narrowing towards tips, which are rounded and slightly splayed outwards; claws not greatly modified.

Acknowledgment

I would like to acknowledge Mr R Gutteridge for preparing the figure.

Reference

WATTS, C. H. S. 1998. Revision of Australian *Enochrus* Thomson (Coleoptera: Hydrophilidae). *Records of the South Australian Museum* **30**(2): 137–156.

C. H. S. WATTS, South Australian Museum, North Terrace, Adelaide, 5000.

Records of the South Australian Museum **32**(1): 119, 1999.

MUSEUM VICTORIA

THREE NEW GENERA AND FIVE NEW SPECIES OF DYTISCIDAE (COLEOPTERA) FROM UNDERGROUND WATERS IN AUSTRALIA

C. H. S. WATTS AND W. F. HUMPHREYS

WATTS, C. H. S. & HUMPHREYS, W. F. 1999. Three new genera and five new species of Dytiscidae (Coleoptera) from underground waters in Australia. *Records of the South Australian Museum* 32(2): 121–142.

Three new genera and five new species *(Nirridessus pulpa, N. windarraensis, N. lapostaae, Tjirtudessus eberhardi* and *Kintingka kurutjutu)* of stygobiontic beetles of the family Dytiscidae, subfamily Hydroporinae, tribe Bidessini, from relatively shallow, calcrete aquifers at Paroo near Wiluna, and at Windarra near Laverton in Western Australia, are described and figured and their relationship with other Bidessini discussed. Two different species of bidessine larvae were also collected and are described and figured. The species are members of a rich, recently discovered, relictual stygofauna, predominantly of Crustacea and Oligochaeta, inhabiting calcretes lying along the line of the Lake Way-Lake Carey palaeodrainage channel.

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The presence in both fresh and brackish waters of communities of animals living in subterranean water bodies is well known (Botosaneanu 1986; Marmonier *et al.* 1993), but the presence of rich subterranean faunas, both aquatic and terrestrial, in arid Australia has only recently been established (Humphreys 1993a, 1993b, 1993c, in press a), and their derivation debatable (Humphreys in press c)

The Australian aquatic systems either contain faunas of predominantly marine derivation inhabiting anchialine waters (Humphreys 1993b, in press a, in press c; Yager and Humphreys 1996; Poore and Humphreys 1992; Bruce and Humphreys 1993; Bradbury and Williams 1997), or faunas comprising predominantly freshwater lineages inhabiting the groundwater in the shield regions (Poore and Humphreys 1998; Humphreys in press c; Wilson and Keable in press). The faunas respectively appear to be associated with those of the Tethys sea (Humphreys 1993b, in press b, in press c; Yager and Humphreys 1996) and Gondwana (perhaps Pangea; Poore and Humphreys 1998; Humphreys in press c). We report here the discovery of populations of five new species in three new genera of Coleoptera (Dytiscidae, Hydroporinae) living in calcrete aquifers occurring along the line of the large Lake Way–Lake Carey palaeodrainage channel. The dytiscids have been collected from Paroo, near Wiluna, and from Windarra, c. 345 km to the southeast in central Western Australia where they occur in communities comprising Syncarida, Amphipoda, Copepoda, Ostracoda and Oligochaeta.

Abbreviations used

BES	Prefix for field numbers.
GSWA	Prefix for Geological Survey of Western Australia monitoring bore number.
OP	Prefix for piezometer number in the Windarra Calcrete Quarry associated with the Murrin Murrin Nickel Cobalt Project run by Anaconda Operations Pty Ltd. (Dames and Moore 1998).
SAMA	South Australian Museum, Adelaide.
WAM	Western Australian Museum, Perth.

Systematics

Key To Australian Species Of Stygobiontic Bidessini

1. — Body length >3.0 mm; pronotum wider than elytra (Fig. 6); protibia bow-shaped (Fig. 6) ... *Tjirtudessus eberhardi* sp. nov.

   — Body length < 3.0 mm; pronotum same width or narrower than elytra (Figs 3–5); protibia triangular (Figs 3–5) 2

2. — Body length approximately 1.0 mm, surface strongly reticulate, legs stout, without swimming hairs on fore and

midlegs (Fig. 7) .... *Kintingka kurutjutu* sp. nov.

— Body length >1.2 mm, surface at most with weak reticulation, legs normal, all with swimming hairs (Figs. 3–5) .... *Nirridessus* 3

3. — Pronotal plicae strong with inward excavations, metatrochanters pointed, basal two metatarsal segments longer in combination than apical three (Figs 3, 14). .....*N. pulpa* sp. nov.

— Pronotal plicae weak, area between them without excavations, metatrochanters rounded, basal two segments of metatarsi in combination equal to or shorter than apical three (Figs 4, 7, 12, 13) 4

4. — Body length > 2.0 mm; eye remnant small, triangular..... .....*N. windarraensis* sp. nov.

— Body length < 2.0 mm; eye remnant reduced to a single suture .... *N. lapostaae* sp. nov.

Tjirtudessus gen. nov.

Description

Bidessini. Relatively flat, narrowed at base of pronotum/elytra, eyeless. Head large, without strong sculpture, lacking cervical line. Pronotum very wide, wider than elytra, smooth, basal plicae weakly impressed. Elytron elongate, smooth, evenly covered with very small punctures each with a small seta; epipleuron without basal carina. Hindwing vestigial. Maxillary palpus elongate with large apical segment about same length as segments one to three combined. Labial palpus moderately elongate with apical two segments subequal. Prothoracic process arched, not reaching mesothorax, apical half spatulate. Post-coxal plates with very weak coxal lines, without punctures, adpressed to first abdominal segment. Post-coxae and first and second sternites fused. Protibia widest in middle; protarsi pseudotetramerous. Metatrochanter large, wholly exposed. Metatibia curved, widening towards apex; tarsi elongate; claws equal, very weak.

Etymology

Western Desert Language of the region: *tjirtu*, a beetle-like insect found swimming in water holes; *dessus*, the suffix of the type genus of the tribe, *Bidessus*.

Remarks

Separated from the other eyeless Bidessini described here by its large size, very broad head and pronotum, weak pronotal plicae and metacoxal lines, and non-triangular shape of the protibiae.

Tjirtudessus eberhardi sp. nov.

Description (number examined, 3) Col. Pl. and Figs 6, 11, 15.

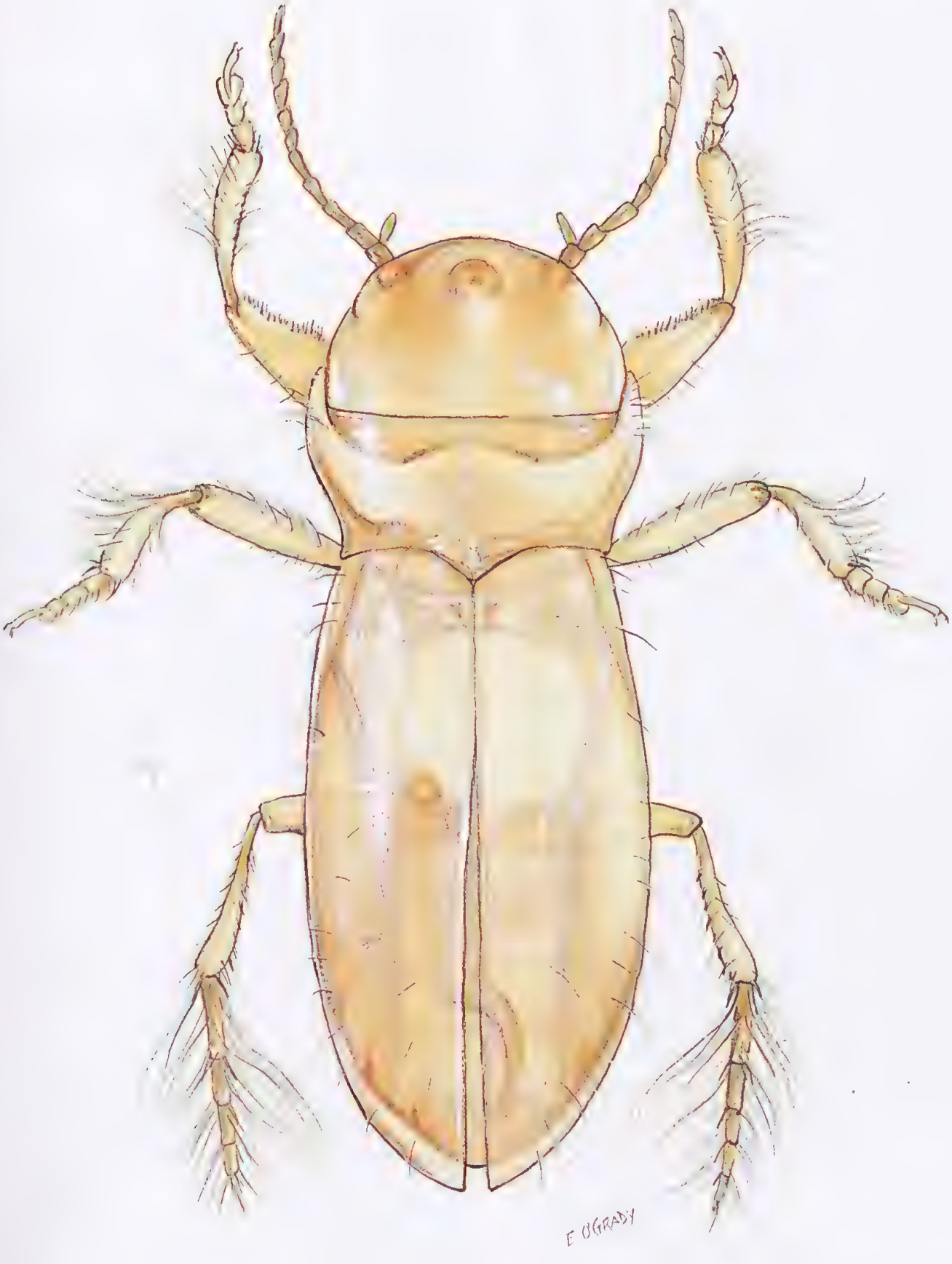
Habitus. Length 3.2–3.5 mm. Strongly constricted at junction of pronotum/elytra; relatively flat; eyeless; uniformly light testaceous. Hindwing vestigial, about half length of elytron.

Head. Large, smooth with a very fine reticulation and sparse weak punctures, subparallel in posterior half, sides with small triangular/oval area outlined by dark sutures in middle near anterior edge. Antenna relatively stout, basal two segments largest, third segment longer and narrower, then progressively shorter and stouter to penultimate, apical segment a bit longer and narrower than penultimate, each segment with some very small setae on inside apically. Maxillary palpus elongate with apical segment large, a little shorter than segments one to three combined, three long setae on outer side and some sensilla towards tip, tip truncated. Labial palpus moderate, apical two segments subequal.

Pronotum. Very broad, wider than elytra, anterolateral angles projecting strongly forward, base quite strongly narrowed, posterolateral angles produced backwards, smooth, with sparse, very weak punctures and a row of stronger punctures along front margin, basal plicae very weakly impressed, only visible in some lights, with row of long setae laterally, denser towards front.

Elytra. Not fused, lacking inner ridges. Elongate, widest behind middle, smooth, sparsely but evenly covered with very small punctures each with a small seta, row of long setae near lateral edge, a few additional long setae more frequent towards sides, some setiferous micropunctures at base and near apex. Epipleuron very broad in anterior fifth, then rapidly narrowing to be virtually absent over rest of elytron..

Ventral surface. Prothoracic process relatively broad, strongly narrowed between coxae, not reaching mesothorax, apical half spatulate, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae meet. Metathorax bluntly triangular in front in



COLOUR PLATE. Adult *Tjirtudessus eberhardi*. Length 3.2–3.5 mm. Artist: Elyse O'Grady.

midline, wings very narrow, virtually absent. Metacoxal plates large, not differentiated into raised central portion and lateral portion, metacoxal lines very short and weak, widely spaced, almost obsolete; punctures very sparse, very weak; closely adpressed to first abdominal sternite. First and second sternites fused, sutural line virtually obliterated, sternites three to five mobile, very sparsely covered with small seta-bearing punctures, sternites three and four with a large central seta or bunch of setae.

Legs. Smooth, without reticulation or punctures. Profemur moderately broad, with a sparse row of thin spines on anterior and posterior edges, a short row of short stout closely spaced spines on front edge at apex; protibia moderately broad, inner edge straight, outer edge bowed, widest near middle, where it is about four times its basal width, with several stout spines at apex, a closely spaced row of small peg-like spines on inner edge and a row of long swimming hairs along outside edge; protarsi with fourth segment very small and hidden within deeply lobed third segment, basal segment broadest, apical segment long and relatively thin, segments one to three with adhesive setae, claws short and simple. Midleg as for foreleg except for lack of small spines. Metatrochanter large, broadly oval, wholly exposed; metafemur elongate, lacking spines, a few short setae; metatibia strongly curved, widening towards apex, a row of about seven relatively long spines on inner edge, two large spines on inner apex, a row of long swimming hairs on ventral surface and a few scattered spines on outer edge; tarsi elongate, with swimming hairs on two sides, basal segment longest, apical segment a little longer than fourth, segments one and two in combination a little longer than others; claws weak (Fig. 15).

Male. Antennae a little stouter, pro- and mesotarsi a little stouter, three basal segments covered on ventral surface with small adhesive setae. Central lobe of aedeagus narrow, narrowing rapidly in apical fifth; paramere broad, two-segmented, apical segment with pronounced, narrow, apical lobe (Fig. 11).

Types

Holotype: ♂. BES 6026, GSWA Bore # 6(B) Paroo Station 25/6/98, 26°26'S 119°47'E, collected by S. M. Eberhard, in spirit, WAM. Registration number WAM 99/60.

Paratype: ♂. Same data as holotype, mounted on slide, WAM. Registration number WAM 99/61.

Associated specimen: ♂. BES 5999 GSWA Bore # 15(A), trap, Paroo Station 25/6/98, 26°24'S 119°46'E, collected by S. M. Eberhard, in spirit, SAMA.

Etymology

Named after Stefan Eberhard in recognition of his expertise and enthusiasm in collecting subterranean fauna.

Nirridessus gen nov.

Description

Bidessini. Broadly elongate, flattened, narrowing somewhat at base of pronotum. Head broad, without strong sculpture, lacking cervical line. Pronotum with sparse weak punctures, basal plicae moderately to strongly impressed. Elytra subparallel, with fine dense punctures; epipleuron quite rapidly narrowing before middle, without basal carina. Hindwing vestigial. Maxillary palpus robust, apical segment equal in length to other three combined. Labial palpus short, stout, apical segment about twice length of penultimate segment. Pronotal process arched, not reaching metathorax, apical half spatulate. Metacoxal plates with relatively short, widely separated coxal lines, weakly granulate/punctate, adpressed to first abdominal sternite. Metacoxal plates and first two sternites probably fused. Protibia strongly triangular; protarsi pseudotetramerous. Metatrochanter large, completely exposed. Metatibia curved, thickening apically; tarsal segments variably elongate; claws equal, weak.

Etymology

Western Desert Language of the region: *Nirri-nirri*, a general term for beetle; *dessus*, suffix of the type genus of the tribe, *Bidessus*.

Remarks

Separated from *Tjirtudessus* by its less expanded head and pronotum (Figs 3–5), relatively strong pronotal plicae, triangular pro- and mesotibiae and presence of a row of large punctures adjacent to the elytral suture; and from *Kintingka* by its larger size, less robust legs, much weaker reticulation, much sparser setae and the presence of swimming hairs on all legs.

Type species

Nirridessus pulpa sp. nov.

Nirridessus pulpa sp. nov.

Description (number examined, 3) Figs 3, 10, 14.

Habitus. Length 2.0–2.2 mm. Elongate, flattened; pronotum broad, narrowing somewhat at base; uniformly testaceous. Hindwing vestigial, reduced to about one quarter length of elytron.

Head. Broad, small; narrow triangular area delineated by dark sutures in middle at edge; very weak reticulation; punctures sparse, weak, row of punctures running backwards from above antennal base. Antenna relatively stout, robust, basal two segments largest, third and fourth smaller then slowly increasing in size to penultimate, apical segment a little longer than penultimate; a few small setae near apex of each segment. Last segment of maxillary palpus elongate, tip truncated, a few small setae near tip.

Pronotum. Broad, a little narrower than elytra; narrowing behind, strongly extended forward at anterolateral angles; very sparse weak punctures and a few larger punctures along front edge; two strongly impressed basal plicae, curving slightly inwards, which reach about half way along pronotum, a depression inwards from each plica at their bases; row of long, thin setae in front half at edges.

Elytra. Fused, lacking inner ridges; subparallel; with sparse small setiferous punctures, small areas of micropunctures at apex and base, a row of much larger weakly impressed punctures beside suture; sides of elytra strongly vertical with scattered, short, fine setae; row of long thin setae at edge, denser towards front.

Ventral surface. Pronotal process arched in lateral view, highest (viewed ventrally) between coxae, apical half narrowly spatulate, narrowing between coxae; not reaching metathorax. Metathorax weakly reticulate, a few fine punctures; sharply triangular in midline in front; wings very narrow, subobsolete, metacoxal plates with weakly raised central portion; coxal lines well separated, weakly diverging anteriorly, reaching to between one half and one third way to mesosternum; weakly reticulate, virtually impunctate; adpressed to abdominal sternite. Metacoxal plates and first and second sternites fused but sutures evident, other sternites free, sternites three and four with central group of setae, otherwise virtually without setae; sparsely and weakly punctate. Epipleuron very broad in front quarter, narrowing quite rapidly to middle then thin to apex, difficult to differentiate from disc, without basal carinae.

Legs. Protibia triangular, about four times as broad at apex than at base which is very narrow, with long swimming hairs; profemur with row of closely spaced small spines on front margin in apical one third to one half with scattered larger spines; protarsi weakly expanded, the fourth segment very small and hidden within deeply bilobed third segment; adhesive setae weak or absent; claws weak. Midleg similar but without small spines. Metatrochanter large, completely exposed, tapering to a broad point, well separated from femur at apex; femur narrowly elongate, anterior edge straight, impunctate, without spines; tibia strongly curved, thickening apically, with a row of long setae in apical half; segments relatively stout, progressively smaller towards apex, apical segment a little longer than fourth, basal two segments longer in combined length than apical three, with two rows of long setae and a number of stout setae at apex of first four segments; claws weak, equal in length (Fig. 14).

Male. Appendages and legs as for female. Central lobe of aedeagus narrow, weakly narrowing to rounded, slightly upturned tip; parameres broad, two-segmented, apical segment with pronounced narrow apical portion (Fig. 10).

Types

Holotype: ♂. BES 6032, Bore # GSWA 5, Paroo Station, 25/6/1998, 26°26'S 119°46'E, collected S. M. Eberhard, in spirit, WAM. Registration number WAM 99/72

Paratypes 3: 1, ♂. BES 6015, Bore # GSWA 6(A), Paroo Station, 25/6/1998, 26°26'S 119°46'E, collected by S. M. Eberhard, lacking head, mounted, WAM. Registration number WAM 99/73; 2, ♀. BES 6002, Bore # GSWA 15(C), trap, Paroo Station, 25/6/1998, 26°24'S, 119°46'E, collected by S. M. Eberhard, in spirit, WAM. Registration number WAM 99/74, ♂, SAMA.

Etymology

Western Desert Language of the region: *pulpa*, "cave".

Remarks

Nirridessus pulpa differs from both *N. windarraensis* and *N. lapostaae* in its much stronger pronotal plicae, much more pointed metatrochanters, narrower more elongate metafemora and stouter metatarsi with relatively short apical segments.

Nirridessus lapostaae sp. nov.

Description (number examined 10) Figs 4, 9, 12.

Habitus. Length 1.3–1.5 mm. Elongate, pronotum narrowing strongly at base; uniformly very light testaceous. Hindwing vestigial, reduced to about one third length of elytron.

Head. Broad, parallel-sided in basal half; rapidly narrowing forward of area where eye would be; a short dark suture at each side in middle at edge; very weak reticulation; punctures sparse, weak, row of setiferous punctures running backwards from above antenna base. Antenna relatively stout, robust, basal two segments broad, third and fourth smaller, then progressively widening until penultimate, apical segment thinner and longer, a few small setae near apex of each segment. Tip of last segment of maxillary palpus truncate, a few small setae towards tip.

Pronotum. Broad in front, narrowing quite markedly behind, strongly extended forward at anterior lateral angles, very sparse weak punctures and a few larger punctures towards front edge; two finely impressed basal plicae, straight, reaching about a third way along pronotum; row of long, thin setae in front half at edges and on forward extensions.

Elytra. Not fused but tightly locked, lacking inner ridges; sides subparallel; with very fine, sparse punctures each with a small seta, a few punctures with longer setae; moderately covered with micropunctures at base and apex, a row of much larger weakly impressed punctures beside suture; sides of elytra quite strongly vertical; with row of long thin setae at edge, denser towards front.

Ventral surface. Pronotal process arched in lateral view, highest point (viewed ventrally) between coxae, apical half broadly spatulate, narrowing between coxae, not reaching metathorax. Metathorax with a few very small punctures; quite sharply triangular in midline in front, wings very narrow, subobsolete. Metacoxal plates with weakly raised central portion; metacoxal lines weak, well separated, diverging in anterior third, reaching about halfway to mesosternum; sparsely punctate; adpressed to first abdominal sternite. Metacoxal plates and first and second sternites fused but sutures evident, other sternites free, sternites three and four with central group of setae, otherwise virtually without setae; virtually impunctate. Epipleuron very broad in front quarter, narrowing quite rapidly to middle, then thin to apex, difficult to differentiate from disc.

Legs. Protibia about five times as broad at apex than at base which is very narrow, with long swimming hairs, row of closely placed small spines on most of inner margin and some large spines towards apex; profemur with row of closely spaced small spines on front margin in apical one third, with scattered larger setae; protarsi quite strongly expanded, the fourth segment very small and hidden within deeply bilobed third segment, adhesive setae weak or absent; claws weak. Midleg similar except for less strongly expanded tarsi and lack of small spines. Metatrochanter large, completely exposed, elongate oval, well separated from femur at apex; femur relatively narrow, anterior edge weakly sinuate, impunctate, without spines; tibia strongly curved, thickening apically, with a row of long setae in apical half; segments elongate, progressively smaller towards apical segment which is a little longer than penultimate, combined length of basal two segments approximately equal to other three, two rows of long setae and a number of stout setae at apex of first four segments; claws weak, outer one slightly smaller than other (Fig. 12).

Male. Appendages and legs as for female. Central lobe of aedeagus moderately broad, concave above, narrowing rapidly close to tip; parameres moderately broad, two-segmented, apical segment with pronounced narrow apical portion (Fig. 9).

Types

Holotype: ♂. BES 6712, piezometer OP122, Windarra W.A. 28°28'40"S 122°07'40"E 18/11/1998, collected by W. F. Humphreys, in spirit, WAM. Registration number WAM 99/65.

Paratypes 6: 1, ? same data as holotype, WAM, registration number WAM 99/66, in spirit; 1, ♀. BES 6548, piezometer OP124, Windarra W.A. 28°29'04"S 122°07'22"E, 18/11/1998, WAM, registration number WAM 99/67, in spirit; 1, ♂. same data, mounted, SAMA; 1, ♀. BES 6559, piezometer OP123, Windarra W.A. 28°28'46"S 122°08'08"E, 18/11/1998, in spirit, WAM, registration number WAM 99/68; 1, ♀. BES 6564, piezometer OP122, Windarra W.A. 28°28'40"S 122°07'40"E, 19/11/1998, in spirit, WAM, registration number WAM 99/69; 2, ♀. BES 6549, piezometer OP122, Windarra W.A. 28°28'40"S 122°07'40"E, 18/11/1998, in spirit, WAM, registration numbers WAM 99/70 & 99/71. All collected by W. F. Humphreys.

Associated specimens: 1, ♂. BES 6712 same data as holotype, in spirit, damaged, SAMA; 1, ♀. BES 6549, piezometer OP122, Windarra W.A.

28°28'40"S 122°07'40"E, 18/11/1998 in spirit, SAMA; fragments of two specimens, same data, in spirit, WAM.

Etymology

Named after Daniella LaPosta of the South Australian Museum for her essential but unsung accounting help and skills.

Remarks

Nirridessus lapostaae differs from *N. pulpa* by its much weaker pronotal plicae and the shape of the midleg. It is more similar to *N. windarraensis* from which it differs in its smaller size, more reduced eye remnant, broader pronotal process, stouter pro- and mesotarsi, relatively shorter apical segment of metatarsi and stouter antennae.

Nirridessus windarraensis sp. nov.

Description (number examined 4) Figs 5, 8, 13.

Habitus. Length 2.2–2.3 mm. Elongate, eyeless, pronotum constricted at base, uniformly light testaceous. Hindwing vestigial, reduced to about one third length of elytron.

Head. Broad, straight-sided in basal half; a very narrow triangular area delineated by dark sutures in middle at edge; punctures sparse, weak, two or three rows of small setiferous punctures running backwards from above antenna base.

Pronotum. Broad, a little narrower than elytra, narrowing smoothly to base, posterolateral angles right angled, anterolateral angles strongly extended forward; very sparse weak punctures; plicae weak, almost straight, reaching to about halfway along pronotum; sparse row of long, thin setae in front half at edges with concentration on anterolateral projections.

Elytra. Elytra not fused but tightly locking, lacking inner ridges; elongate, subparallel in middle half; with sparse weak setiferous punctures, a row of much larger weakly impressed punctures beside suture, quite large areas of micropunctures near base and near apex, sparse over rest of elytra; sides of elytra quite strongly vertical with short fine setae; with row of moderately long thin setae at edge, denser towards front. Antenna moderately stout, basal two segments relatively broad, third segment narrowly triangular, successive segments gradually shortening and thickening, except apical segment which is bit longer than penultimate, a cluster of small setae near apex of each segment. Apical segment of maxillary palpus weakly bifid at tip, oblique ring of small setae near tip.

Ventral surface. Pronotal process relatively narrow, strongly arched in lateral view, highest point (viewed ventrally) between mesocoxae, apical half spatulate, narrowing between coxae, not reaching metathorax. Metathorax with a few scattered weak punctures; broadly pointed in midline in front, wings very narrow, subobsolete. Metacoxal plates large, with weakly raised central portion, coxal lines weak, well separated, moderately diverging in anterior half; reaching to about one third way to mesosternum; smooth, virtually impunctate except a few towards midline; adpressed to first abdominal sternite. Metacoxal plates and first and second sternites fused, suture lines between first and second sternites obliterated laterally, other sternites free, sternites three and four with central group of setae, otherwise virtually without setae; weakly and very sparsely punctate. Epipleuron broad in front quarter, narrowing quite rapidly to middle then thin to apex, difficult to differentiate from disc.

Legs. Protibia triangular, about five times as broad at apex than at base which is very narrow, with long swimming-hairs, row of closely spaced small spines on inner margin and some strong spines towards apex; profemur with row of closely spaced small spines on front margin in apical one third, with scattered larger setae; protarsi weakly expanded, the fourth segment very small and hidden within deeply bilobed third segment, adhesive setae small; claws weak. Midleg similar except for lack of fine spines. Metatrochanter large, completely exposed, oval, well separated from femur at apex; femur relatively narrow, anterior edge weakly sinuate, virtually impunctate, without spines; tibia strongly curved, thickening apically, with a row of long setae in apical third; segments relatively thin, apical one longer than penultimate, basal two segments shorter in combined length than apical three, with two rows of long setae and a number of stout setae at apex of first four segments; claws weak, inner one slightly shorter than outer (Fig. 13).

Male. Appendages and legs as for female. Central lobe of aedeagus narrow, concave on top, narrowing rapidly near apex to narrow tip; parameres not particularly broad, two-segmented, apical segment with pronounced narrow apical portion (Fig. 8).

Types

Holotype: ♂. BES 6712, piezometer OP122, Windarra W.A. 28°28'40"S 122°07'40"E 18/11/

1998, collected by W. F. Humphreys, in spirit, WAM. Registration number WAM 99/62.

Paratypes 2: 1, ♂. BES 6549, piezometer OP122, Windarra W.A. 28°28'40"S 122°07'40"E, 18/11/1998, mounted on slide, WAM, registration number WAM 99/63; 1, ♂. BES 6559, piezometer OP123, Windarra W.A. 28°28'S 122°08'08"E, 18/11/1998, in spirit, WAM, registration number WAM 99/64. All collected by W. F. Humphreys.

Associated specimens: 1 ♀. BES 6549, same data as paratype, in spirit, SAMA; parts of two specimens, BES 6558, piezometer OP123 same data as above.

Etymology

Named after the type locality.

Remarks

Separated from *N. pulpa* by its much weaker pronotal plicae and the structure of the midleg. From *N. lapostaae* it differs in its larger size, more parallel-sided elytra, presence of small triangular areas where eyes would be, narrower pronotal process, more elongate metatarsi, and less robust pro- and mesotarsi.

Kintingka gen. nov.

Description

?Bidessini. Narrowly oval, weakly flattened, eyeless. Head very broad, strongly reticulate, lacking cervical line. Pronotum strongly reticulate, basal plicae finely, sharply impressed. Elytron strongly reticulate, with numerous short fine setae, epipleuron without basal carina. Hindwing vestigial. Maxillary palpus broad, apical segment greater than length of other three combined. Labial palpus stout, approximately the same size and length as maxillary palpus. Pronotal process moderately arched, apical half spatulate, not reaching mesosternum. Metacoxal plate strongly reticulate, coxal lines weak; coxal lobes adpressed to but possibly not fused to first abdominal sternite. First two abdominal sternites possibly fused. Protibia strongly triangular; protarsi pseudotetramerous. Metatrochanter completely exposed; metatibia stout, straight, expanding a bit towards apex; tarsal segments robust; claws equal, very small. Fore and midlegs without swimming hairs.

Etymology

Western Desert Language of the region; *Kintingka*, a beetle-like insect found swimming in water holes.

Remarks

Separated from the other eyeless Bidessini described here by its small size, strong reticulation, relatively dense covering of setae, stout palpi, stout legs and lack of swimming hairs on fore and midlegs.

Kintingka kurutjutu sp. nov.

Description (number examined, 1) Figs 7, 16.

Habitus. Length 1.0 mm. Narrowly oval, weakly flattened; uniformly testaceous; hindwing vestigial.

Head. Broad, bulges outwards at sides behind where eyes normally are; strongly reticulate; a few setiferous punctures on each side about where inner edge of eye would be; small suture at side of head in middle. Antenna stout, basal two segments largest, next two smallest, then slowly increasing in size to penultimate, apical segment twice length of penultimate; a few very small setae on inside at apex of each segment. Maxillary palpus very broad; apical segment greater than length of other three combined; tip narrowed, truncated, a diagonal row of a few setae towards tip. Labial palpus broad, approximately the size and length of maxillary palpus.

Pronotum. Broad, narrowing towards rear; anterolateral angles strongly projecting forward; posterolateral angles bluntly produced backwards; reticulate, sparsely covered with very small punctures each with a relatively long fine setae; pronotal plicae very fine, sharply impressed, reaching half way along pronotum.

Elytra. Not fused; without inner ridge; reticulate; moderately covered with minute punctures, each with a relatively long fine setae; with a row of long thin setae at edges.

Ventral surface. Pronotal process moderately arched in lateral view, highest point (viewed ventrally) between coxae; spatulate in apical half; very narrow between coxae; not reaching metasternum. Mesocoxae meet. Metasternum sharply triangular in midline in front; wings very narrow; reticulate; a few relatively long setae in mid line. Metacoxal plate not raised in midline; coxal lines virtually absent; strongly reticulate; with sparse, very small punctures, more frequent towards midline, each with a quite long seta; adpressed to, but possibly not fused to first abdominal sternite. First and second sternites

fused, with obvious suture; sternites three to five free, covered with rather long setae; three and four with small patch of very long setae in middle. Epipleuron rather narrow in front, progressively narrowing to apex.

Legs. Foreleg very stout; femur strongly reticulate, virtually without spines; tibia triangular, about five times as broad at apex than at base; reticulate; a row of closely spaced small spines on inner margin and some strong spines towards apex; tarsi with fourth segment very small and hidden within deeply bilobed third segment, basal three segments moderately expanded, almost bare of setae ventrally, apical segment stout; claws rather weak. Midleg very stout; femur and tibia strongly reticulate; tibia and tarsi a little less stout than on foreleg. Metatrochanter reticulate, completely exposed, very large, inner edge rounded, outer edge straighter, apex well separated from femur; femur reticulate, stout, without setae, with one spine at apex on inside; tibia stout, straight, much narrower at base than apex, with numerous spines, some strong; tarsi robust, with numerous stout spines, segments progressively smaller except apical which is a bit smaller than fourth, basal two segments in combination about same length as other three; claws equal, extremely small. Fore and midlegs without swimming hairs, swimming hairs weakly developed on metatibia and tarsi (Fig. 16).

Male. Not known.

Types

Holotype: ♀. BES 6032, GSWA 5, Paroo Station 25/6/1998, 26°26'S 119°46'E, coll. S. M. Eberhard, mounted on slide, WAM. Registration number WAM 99/75.

Etymology

Western Desert Language of the region; *kurutjutu,* "blind".

Larva form 1. Figs 17–22

Length 4.2 mm (not including urogomphi). Light testaceous, head darker than rest; eyeless; head proportionally very broad. Head capsule broad, relatively round without marked neck region, sides with some quite strong spines; nasal large, as long as the rest of head, broad, without lateral notches but with a prominent downward pointing small spine/tooth on each side near middle, band of small spines/teeth around front edge ventrally (Fig. 19). Mandibles relatively strong. Labium small, with a few long setae, palpus long and slender (Fig. 20). Maxillary stipe simple, palpus long and slender (Fig. 18). Antenna a little shorter than maxillary palpus, second and third segments same length, apical segment smaller, accessory appendage well developed, a little shorter than apical segment. Thoracic segments weakly sclerotized, sparse row of quite strong setae on posterior edges dorsally. Abdominal segments weakly sclerotized, quite numerous strong setae on posterior edges dorsally and at sides, microsetae arranged in rather short irregular lines. Apical segment with moderate siphon. Trachea in siphon and those at sides of abdominal segments of normal size. Urogomphi broken, only a short basal portion of one remaining which has a long ventral setae near base, a very small dorsal seta near base and a slight notch on the outer side which is the attachment point of a seta which has been broken off; shaft microreticulate, meshes moderate with very fine microsetae along edges of reticulation, becoming noticeably stronger near base. Legs long, relatively thin, with standard set of hydroporine primary setae, moderate number of secondary setae, lacking setae TR2 (Nilsson 1987), lacking swimming hairs (Figs 21, 22). A few very long setae on sides of thoracic and abdominal segments, more frequent posteriorly.

Association with adult

We think that this larval specimen is an early final instar that will thicken and elongate considerably before pupation. Most probably it is the larva of *T. eberhardi* since it would seem to be already too large to belong to *N. pulpa.*

Specimen data

1, BES 6017, Bore # GSWA 6(A), Paroo Station, 25/6/1998, 26°26'S 119°47'E, collected by S. M. Eberhard, mounted on slide, WAM.

Larva form 2. Figs 23–29

Length 1.2 mm (not including urogomphi). Almost transparent, head a very light testaceous. Head broad, relatively large, eyeless, without neck region, without lateral spines, with a few very long setae towards front at sides; nasal very broad, lacking lateral notches, about as long as rest of head, row of very large strong setae/teeth around much of ventral edge (Figs 24, 26, 27). Labium small; palpus robust, apical segment narrower in apical half (Fig. 25). Maxillary stipe simple; palpus robust, apical segment small (Fig. 23). Antenna short, stout, apical segment thin, accessory appendage about half length of apical segment. Mandibles relatively thin. Thoracic and

abdominal segments weakly sclerotised; a few moderate setae and some very long ones laterally, more numerous posteriorly; microsetae relatively dense, in long lines. Apical segment with moderate siphon; urogomphi moderately long, two segmented, basal segment with three long setae plus a group of three long setae at apex, apical segment with one long seta attached a short distance from apex; microreticulation meshes large, almost annular, with short fine microsetae along edges. Tracheae absent. Legs relatively stout with only the standard hydroporine set of primary setae, TR2 absent, swimming hairs absent; tarsal claws moderately strong (Figs 28, 29).

Association with adult

All four specimens are similar in size and structure. Their fragile appearance, absence of tracheae, sparseness of abdominal setae, and lack of secondary setae on the legs suggest that they are first instar larvae. If so, their size would associate them with *N. pulpa*. Their very stout cephalic appendages and broad squat nasal are too different from those of form 1 for them to belong to the same species.

Specimen data

1, BES 6028, Bore # GSWA 6(B), Paroo Station, 25/6/1998 26°26'S 119°47'E, mounted on slide, WAM; 1, same data, in spirit, SAMA; 1, BES 6022, Bore # GSWA 6, Paroo Station, 25/6/1998 26°26'S 119°47'E, in spirit, WAM; 1, BES 5994, Bore # GSWA 16, Paroo Station, 24/6/1998 26°26'S 119°44'E, in spirit, WAM. All collected by S. M. Eberhard.

Systematic Relationships

Tribal placement

The small size, lack of a visible scutellum, pronotal process on two planes, pseudotetramerous protarsi and larval nasal, place these new genera in the subfamily Hydroporinae. They all lack defining synapomorphies for the Hydrovatini (incised metacoxal process, very broad pronotal process, modified apical sternite [Biström 1996]), and Hyphydrini (unequal metatarsal claws) and appear, quite clearly, to belong within Bidessini and/or Hydroporini.

We place all three new genera in the Bidessini. Our reasons, in descending order of importance, are as follows.

The two genera whose parameres are known possess the unique Bidessini synapomorphy of two-segmented parameres (Biström 1988, 1996).

The two known larval species lack notched nasals and hence would seem to lie outside of the Hydroporini, if Wolfe's identification of this character state as a synapomorphy for Hydroporini is correct (Wolfe 1985). This is true within Australia. However the larvae of *Haideoporus* and *Morimotoa* which are both subterranean and currently placed in the Hydroporini (a placement supported by their single segmented parameres) do not have notched nasals (Young and Longley 1976; Longley and Spangler 1987; Uéno 1957).

The species lack spines along the outside edge of the metatarsi. Such spines are present in all Australian hydroporini but are absent in all Australian bidessini except for one or two on the basal segment in some species. The usefulness of this character outside Australia or its polarity is unknown (*Hydrovatus* and *Hyphydrus* lack such spines, whereas *Laccornis* has them).

The presence of pronotal plicae. Although found in the Australian hydroporines, *Sternopriscus, Necterosoma* and *Barrethydrus*, this character is more typical of bidessines (Biström 1988).

Open metatrochanter bases. Typical of bidessines but also approached in some hydroporines, particularly the Australian *Paroster, Necterosoma* and *Carabhydrus* and in Hyphydrini. Not present in the Hydrovatini (Biström 1996).

Fusion of metacoxal plates and first and second abdominal sternites. Again almost universally present in the Bidessini but also present in some hydroporines (Biström 1988; Wolfe 1985; Larson and Storey 1994).

Metatibia strongly narrowed at base and, in *Tjirtudessus* and *Nirridessus*, also strongly curved. This is a typical bidessine character but is also present in some Hydroporini including the Australian *Sternopriscus* (Biström 1988; Larson and Storey 1994).

There are three other possible tribal placements that need to be considered.

Smrz (1982) created a separate tribe, Siettitini, specifically for Hydroporinae living below ground and exhibiting such characters as eyelessness, flightlessness, lack of pigment, development of long sensory setae and prosternal process not reaching the mesosternum. Although useful taxonomically, it is widely recognised that this is an artificial classification, grouping together phylogenetically unrelated taxa simply because of common adaptations to an underground existence

(Young and Longley 1976; Pederzani 1995).

Watts (1978) created the tribe Carabhydrini for the peculiar Australian genus *Carabhydrus*. Larson and Storey (1994) discussed this placement, concluding that although some uncertainty regarding its true position remained, it was probably best to consider *Carabhydrus* to be a member of the Hydroporini. We accept their argument and tentative conclusion.

The new genera could be considered as a separate tribe. We can find no good reasons to suggest this.

Relationships within the Bidessini

None of the new genera appears close to any Australian Bidessini. However the presence of pronotal plicae, the form of the parameres, the simple central lobe of aedeagus, the lack of or weak development of elytral setae, the lack of sutural striae, the weak punctation and lack of basal carinae on the epipleura point quite strongly to a relationship to *Limbodessus, Liodessus* or *Boongurrus,* even though the new genera lack a cervical stria, identified by Biström (1988) to be a phylogenetically significant character in the Bidessini, and which is present in *Liodessus* and *Boongurrus.* However this character appears in the process of being lost in *Boongurrus* (Larson and Storey 1994), which is a very small species found in sand and gravel at the headwaters of small streams and shows signs of an incipient underground existence suggesting that this character could have been lost in the truly subterranean genera.

Beyond Australia four genera of subterranean Bidessini (based primarily on the presence of two-segmented parameres [Biström 1988]) have been reported: *Trogloguignotus* Sanfilippo, 1958 from Venezuela; *Comaldessus* Spangler and Barr, 1995 from the United States of America; *Sinodytes* Spangler, 1996 from China; and *Glareadessus* Wewalka and Biström, 1998 from the Persian Gulf region. In addition a species of *Uvarus* Guignot, 1939 *(U. chappuisi* [Peschet 1932]) has been collected from a well in Upper Volta (Burkina Faso). Of these, *U. chappuisi* is little modified from its surface congeners and the two species of *Glareadessus* are not greatly different from *Hydroglyphus* Motschulsky, 1853 (Wewalka and Biström 1998). Both *Trogloguignotus* and *Comaldessus* differ from the Australian genera in the presence of elytral plicae, and in having the prosternal process reaching the metasternum. *Sinodytes* is more similar but differs in its four segmented pro- and mesotarsi, the prosternal process reaching the metasternum, relatively strong punctation and, from *Tjirtudessus* and *Nirridessus,* lack of swimming hairs on legs. None of these non-Australian genera appear to be close to the new Australian ones.

A much more detailed phylogenetic study is needed before a clear idea of the relationships of the new genera is obtained but we predict the sister group, or groups, will be found within the current Australian bidessines, possibly near *Liodessus, Limbodessus* or *Boongurrus.*

Relationships between the new genera and species

The three new genera share a number of characteristics which suggest a relatively close relationship between them within the Bidessini, based on Biström's 1988 review. All lack a cervical stria, a basal carina on the epipleuron, a margined frons, elytral plicae or sutural striae and all have short, moderate to strongly arched pronotal processes not reaching the metasternum which is rarely found in the Bidessini and not found in any Australian genus. This would seem to suggest a relatively recent common origin from within a restricted section of the Bidessini. Unfortunately the polarity of these character states is unknown. They may also, as is likely in the case of the short, arched pronotal process, represent adaptations to a subterranean existence and hence have little phylogenetic content.

Of the five species *K. kurutjutu* appears more distant than the others. Its rounded shape, stout legs and appendages and unusually strong reticulation appear to be characters retained from its terrestrial ancestor and to suggest a more distant phylogenetic origin to the others. In all these characters it most closely resembles *Paroster,* and the blind, terrestrial, *Terradessus,* both in the Hydroporini, although, as argued above, we have placed it in the Bidessini, a position that must be considered tentative until the discovery of the male.

The strikingly similar parameres of the four other species, a character perhaps less subject to evolutionary change in a new environment, suggest a relatively close relationship between them. Within these the large size, cordate shape, subobsolete pronotal plicae and metacoxal lines, and bow-shaped protibiae separate *T. eberhardi* from the remaining species which seem relatively closely related to each other, reflected in our placement of them in the one genus, *Nirridessus.* Within *Nirridessus* the rounded metatrochanters, sinuate metafemora and elongate metatarsi seem,

on a first analysis, to be derived characters and to link *N. windarraensis* and *N. lapostaae* as sister species. They also lack the strong pronotal plica of *N. pulpa.* These differences are quite large in terms of bidessine taxonomy and it is quite possible that future studies will support their separation into two genera.

The two larvae, which we have associated with *T. eberhardi* and *N. pulpa,* are very different with ? *T. eberhardi* having long legs, elongate cephalic appendages, enlarged nasal but without strong spines/teeth in contrast to the stout legs and cephalic appendages and greatly developed spines/teeth on the nasal in ? *N. pulpa,* and, if the associations are correct, support the generic separation of the two species.

In summary we tentatively suggest that *N. windarraensis* and *N. lapostaae* are sister species. *Tjirtudessus* and *Nirridessus* are sister genera with the position of *Kintingka* more distant and problematical.

Adaptations To Subterranean Life

Many species found living underground display certain characteristic traits that are thought to be adaptive to underground life. These include both the reduction or loss of characters (regressive evolution) and the enhancement of others (constructive evolution), which together produce the convergence characteristic of cave-adapted animals, that is termed troglomorphy. These adaptations include morphological, ecological, physiological and behavioural characteristics (Christiansen 1992; Culver et al. 1995).

General shape and size. Enlarged head, flattening of the body and narrowing at the pronotal elytral junction are common features of subterranean Hydroporines. *Tjirtudessus* exhibits these characters to the greatest degree with *Nirridessus* and *Kintingka* seemingly less altered. Size is a character that often changes in animals exhibiting marked adaptation to subterranean life, those living in large voids are larger while those inhabiting interstices are smaller than is typical for their lineage. *Kintingka* is among the smallest Dytiscidae while on the other hand *Tjirtudessus* is unusually large for a Bidessine, only *Bidessodes grossus* approaches it in size within the Australian fauna. Whether these size characteristics reflect the spaces they inhabit or some other aspect of niche partitioning is unknown; nonetheless the size (length) ratios of the two series of sympatric species are well beyond that considered necessary for niche separation, being for Paroo 1.6 and 2.1 (mid-point of range) and for Windarra 1.6.

Eyes. Loss of eyes is typical of subterranean animals. All three genera are eyeless. In some lights "ghosts" of ocelli can be seen in *N. pulpa.* At the sides of the head, where the eyes would have been, there is a cuticular area bounded by sutures. In *T. eberhardi, N. pulpa* and *N. windarraensis* this is a small, narrowly oval area. This is further reduced to a small suture in *K. kurutjutu* and *N. lapostaae.*

Wings. The elytra of *N. pulpa* are fused. In all the other species the elytra separated on dissection/preparation. In most Hydroporinae there is an inner ridge near the side of the elytron, thought to be associated with locking the elytra against the abdomen (Wolfe 1985). This is lacking in the new species suggesting that even in *Tjirtudessus* and *Kintingka* the elytra are normally tightly closed by some other mechanism.

In *T. eberhardi* and the three *Nirridessus* species and probably also in *K. kurutjutu,* the forewing is quite long but narrow, flimsy and veinless. In all five species it is obviously well on the way to being lost.

Sensory structures. All five species have the long thin sensory setae around the body recorded for all subterranean Hydroporinae (Spangler 1986). On the antennae and palpi there are small setae that probably have a sensory function. All the species have concentrations at the base and apex of the elytra of minute setae-bearing punctures. Apart from their very small size and seeming absence in the few terrestrial species we have looked at, these appear normal but they may have a specific sensory function. In *Kintingka* there are a few cuticular sensilla on the top of the head, but otherwise we have been unable to find any sensory organs, such as described by Smrz (1983) for other subterranean Hydroporinae. More detailed investigation of new material may well find more such organs.

Colour. As in most subterranean animals the new genera lack pigment and all are partially transparent, particularly the larvae.

Sculpture. All known subterranean Hydroporinae have smooth shiny surfaces, with weak to very weak punctures or setae on both dorsal and ventral surfaces. Only two, *Trogloguignotus* and *Uvarus,* have raised structures such as plicae or striae. In both *Tjirtudessus* and *Kintingka* pronotal plicae are traceable but very fine, suggesting that they are in the process of being lost. However in *Nirridessus* the plicae are relatively strong and, in *N. pulpa,*

have a well marked excavation inside them. In *Kintingka* the reticulation on both surfaces is unusually strong, even for a terrestrial bidessine. The setae in the dorsal punctures are strong in *Kintingka,* although the density of punctures is not great.

Larvae. Both larval types show the typical loss of eyes and colour of subterranean animals. Compared with Australian terrestrial Bidessini larvae the larger larva form 1 has a disproportionately large head and long legs and a strong nasal. The smaller larva form 2 is most noticeable for its strong development of nasal spines (Fig. 21).

Habitat

All the beetles were taken by plankton net or trap from boreholes in calcrete aquifers associated with the Lake Way–Lake Carey palaeodrainage channel (Fig.1) on the Yilgarn craton of Western Australia.

The palaeodrainage channels in the Yilgarn are old – they contain patches of Permian fluvio/glacial sediments – and were deeply incised into a plateau of Precambrian rocks during the Permian or earlier: there is an absence of sediment between the Permian and Eocene throughout the Western Proterozoic basins (L. Worrall, personal

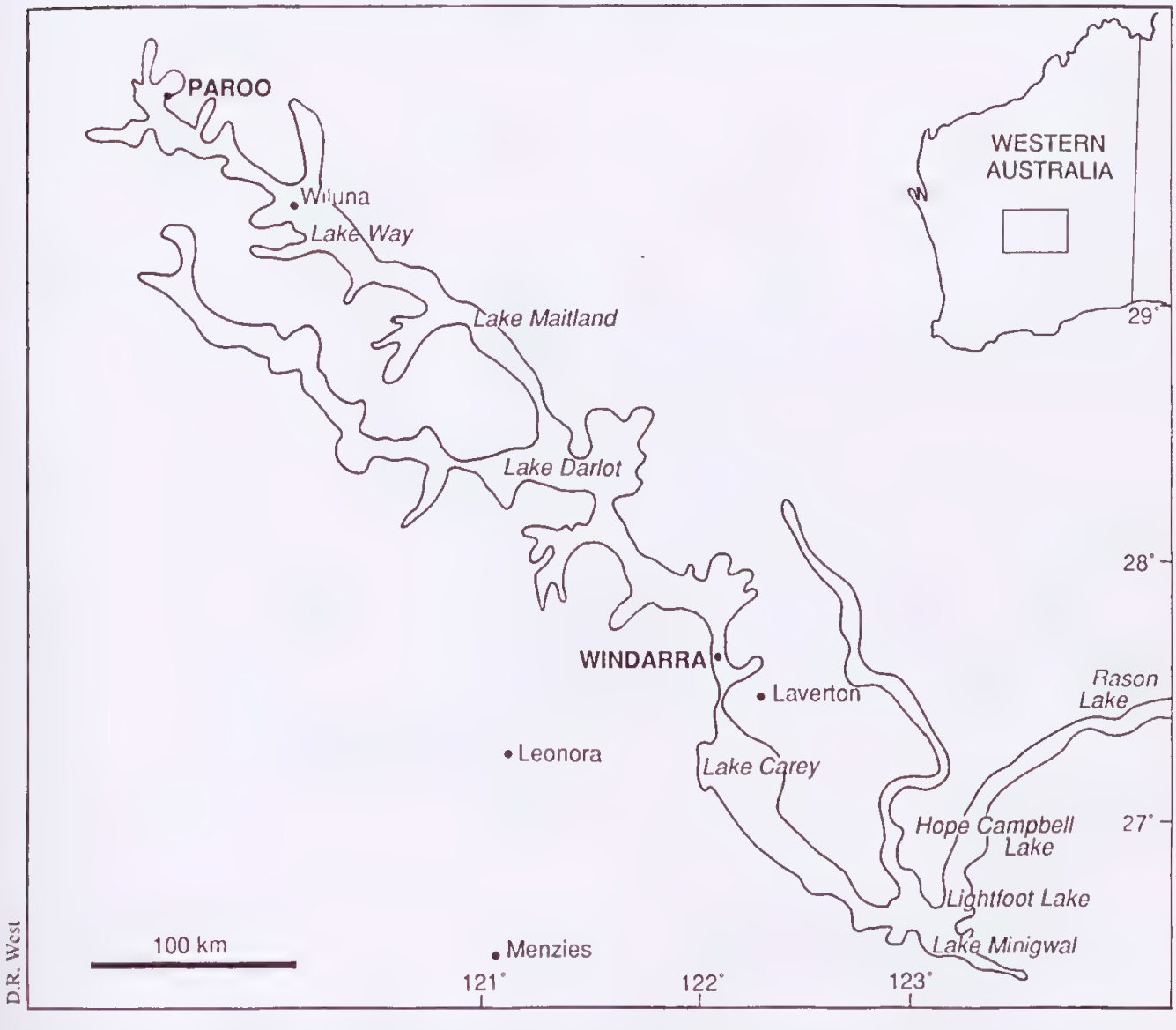


FIGURE 1. Map showing the extent of the Lake Way-Lake Carey palaeodrainage channel on the Yilgarn craton. The channel continues through Rason Lake to the Eucla Basin. The adjacent palaeodrainage channels are not shown. Groundwater calcretes are mostly associated with the 'lakes' (salinas, playas) that overlie the palaeodrainage channel in places. **Inset**: location of the site in Western Australia.

communication 1998). Towards the south the minor palaeodrainage lines probably formed after the uplift of the Darling Plateau and Eocene marine transgressions deeply penetrated the palaeovalleys along the western margin of the Eucla basin (Jones 1990; L. Worrall, personal communication 1998) when conditions were tropical. It is of interest that the amphipods from the southern sites are Ceinidae (J. Bradbury, personal communication 1998), a family of marine ancestry (Barnard and Karaman 1984) while those from the northern site are crangonyctoids, an ancient freshwater lineage (J. Bradbury personal communication).

The northern samples were from an aquifer in Tertiary calcrete deposits on Paroo Pastoral Station (altitude 520 m AHD) in the Paroo sub-basin of the Lake Way Basin in central Western Australia (Figs 1 and 2). All bores from which stygofauna were obtained overlay Proterozoic shale. Locally the calcretes overlay Proterozoic dolomite, sandstone and shale, and are overlain in places by Quaternary alluviums and colluviums (Fig. 2), and this juxtaposition is probably the source from which this possibly old fauna – by analogy with other areas (Humphreys 1993; in press a, in press b; Poore and Humphreys 1998) – invaded these inland-draining palaeochannels. Bores in the Proterozoic and Quaternary facies (Fig. 2) were also investigated but no stygofauna was found.

Calcretes are carbonate deposits forming near the water table in arid lands as a result of concentration processes by near-surface evaporation (Jacobson and Arakel 1986). Groundwater calcretes (Arakel 1996) often

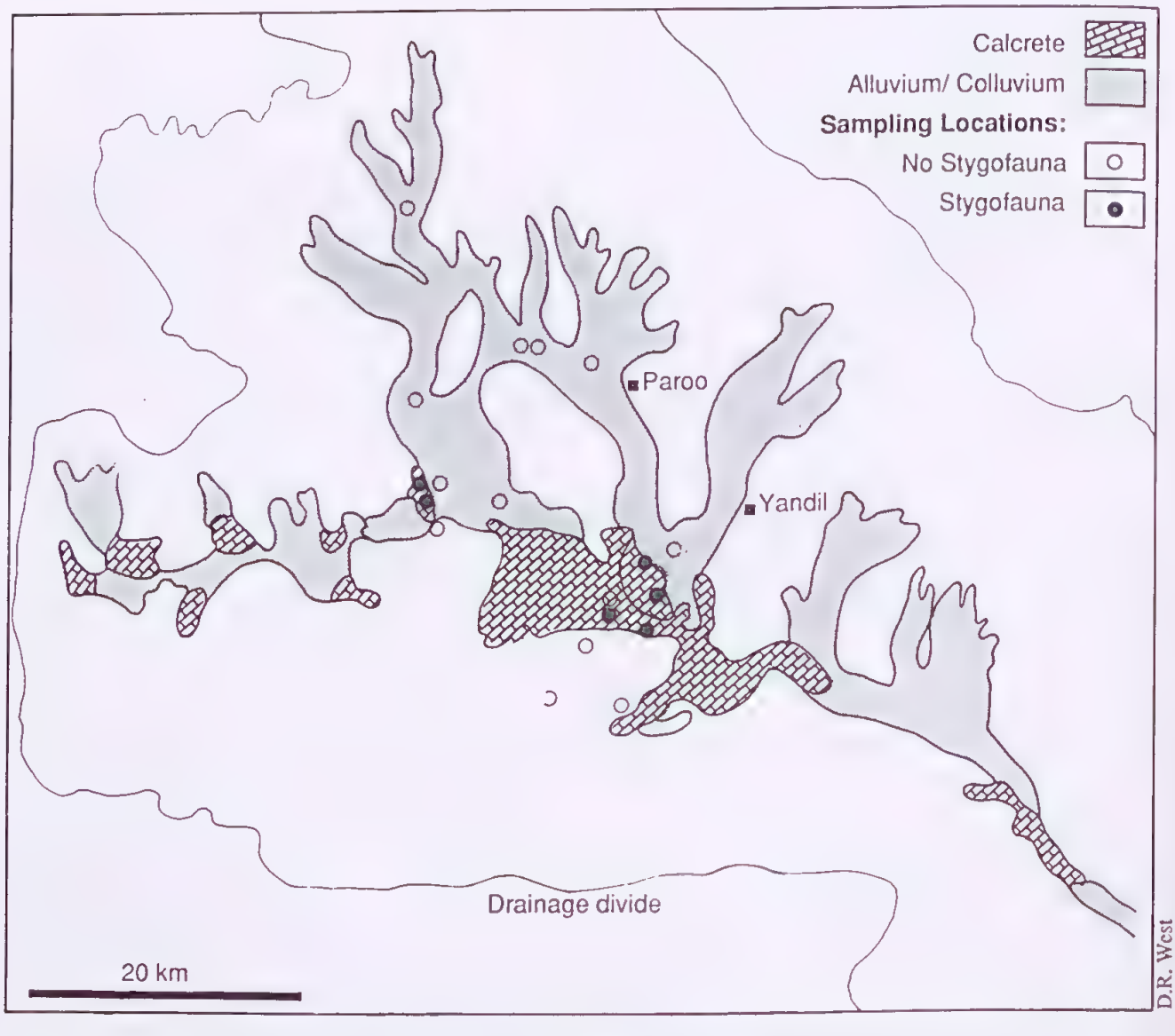


FIGURE 2. Location of the sample sites in the Paroo sub-basin of the Lake Way Basin in Western Australia. **Inset**: location of the site in Western Australia. Base map after Sanders (1973).

TABLE 1. Data for collecting localities.

Bore	Latitude	Longitude	Depth(m)	Comments
GSWA Bore#15	26° 24' 02" S	119° 45' 47" E	27.4	cavernous calcrete/ shale
GSWA Bore#16	26° 25' 31" S	119° 43' 43" E	15.0	shale
GSWA Bore#5	26° 26' 25" S	119° 46' 19" E	22.3	shale
GSWA Bore#6 (A)	26° 26' 02" S	119° 46' 38" E	30.5	observation well, shale
GSWA Bore#6 (B)	26° 26' 02" S	119° 46' 38" E	•	observation well
GSWA Bore#6 (C)	26° 26' 02" S	119° 46' 38" E	•	observation well
OP 113	28° 29' 28.4" S	122° 07' 07.2" E	4.20 (0.05)	piezometer
OP 118	28° 29' 11" S	122° 07' 13" E	5.25 (1.55)	piezometer
OP 122	28° 28' 40" S	122° 07' 40" E	3.50 (0.40)	piezometer
OP 123	28° 28' 46" S	122° 08' 08" E	2.05 (0.15)	piezometer
OP 124	28° 29' 04" S	122° 07' 22" E	3.95 (0.10)	piezometer

develop typical karst features (Barnett and Commander 1985). Such a calcrete aquifer covers c. 90 km^2 of Paroo Station. The upper surface of the calcrete is rubbly and sometimes karstic and so the surface is permeable because of sinkholes and caverns. Opaline silica occurs at about the water table. Below this layer caverns and interconnected conduits have also developed in the friable calcareous material as the result of groundwater circulation. The calcrete varies in thickness between 7.6 and 11.6 m with an average saturation thickness of 4.5 m (Sanders 1973).

Groundwater occurs widely in the Paroo sub-basin and as close to the surface as 4.3 m in places (Table 1). The calcrete is recharged by rainfall through the porous surfaces. Rainfall in the region is low; c. 200 mm per year, and highly episodic with storm rainfalls of 76 mm and 119 mm expected at frequencies of once every two years and five years respectively (Sanders 1973). In consequence the groundwater table varies quite widely between storm events.

When investigated in 1973 – attributes may now differ – the total salinities within the Paroo calcrete ranged from 710–1330 mg L^{-1} TDS when the borefield characteristics were established (Sanders 1973) but was not much stratified within boreholes. There is a general increase in salinity downstream up to 4400 mg L^{-1} TDS. The calcrete aquifers eventually drain to the salt lakes in the Lake Way system which act as evaporation basins.

The southern samples were taken from piezometers (altitude 416–418 m AHD) associated with a calcrete quarry at Windarra (Fig. 1), adjacent to the lower reaches of the Lake Way–Lake Carey palaeodrainage system at depth. In this region no subterranean fauna was recovered from either the Roy-Valais Borefield or the Korong North Borefield developed in aquifers in basal palaeosands overlain by substantial layers of clays in the palaeovalley deposits.

The calcrete deposit at Windarra reaches a maximum thickness of about six metres – it is overlain by c. 1 m of ferruginous, clayey, unconsolidated sand – and is typical of the groundwater calcretes widely occurring in the Australian arid zone. There are well developed karst features within the area covered by the piezometric field that are typical of those found elsewhere in calcrete (Sanders 1973) and in those supporting stygofauna (Poore and Humphreys 1998; W. F. Humphreys, unpublished). In the quarry area the water table is shallow (3.34 m [s.d. 0.89 range 1.90–4.15 below the natural surface,] at the time of sampling) (Table 1). As such the calcrete comprises a highly permeable aquifer with limited saturation thickness. The salinity in the Windarra Calcrete Quarry area ranged from c. 1500–3200 mg L^{-1} TDS at the time of sampling but has been reported as high as 4100 mg L^{-1} TDS in places (Dames and Moore 1998).

Associated Fauna And Biology

The three genera of dytiscids are sympatric at Paroo (Table 2) and two congeneric species are sympatric at Windarra (Table 3) and they are found together with syncarid crustacea (Bathynellacea), crangonyctoid amphipods (gen. nov.; J. H. Bradbury, pers. comm.), phreodrillid oligochaetes (a Gondwanan lineage), cyclopoid copepods and candonine ostracods (Tables 2 and 3). Undoubtedly more comprehensive sampling of the aquifer will add to this fauna, especially at Windarra where the entire volume of water accessible for sampling was only c. 4.4 L.

TABLE 2. The distribution of stygofauna in the Paroo area. Ten bores were sampled from six sites and only one site yielded no fauna. The numbers under 'Wells' denote the number of wells out of 12 from which taxon was sampled. L denotes larvae presumed to represent *N. pulpa* and *T. eberhardi*. Note the more or less complete restriction of stygofauna to bore samples as opposed to open wells.
* = stygofauna, otherwise epigean species.

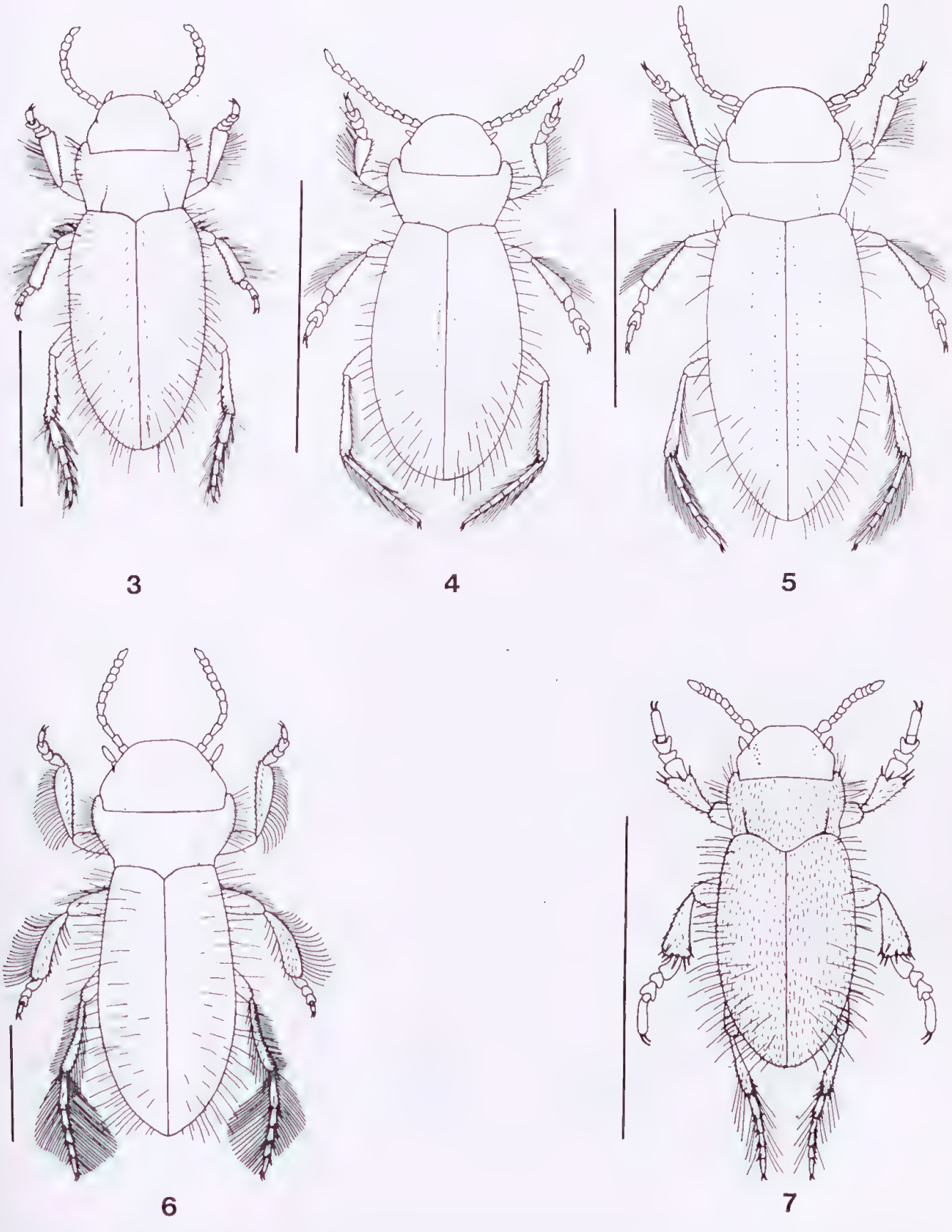
	GSWA Bore	5	6	15	16	20	Wells
Dytiscidae	*Tjirtudessus eberhardi* sp. nov.*	–	+L	+	–	–	–
	Nirridessus pulpa sp. nov.*	+	+L	+	L	–	–
	Kintingka kurutjutu sp. nov.*	+	+	–	–	–	–
Crustacea	Bathynellacea*	–	+	+	–	+	+
Amphipoda	Crangonyctoid*	+	+	+	+	+	–
Copepoda	Cyclopidae	+	+	+	+	+	+
Ostracoda	Cypridinae	–	–	–	–	–	1
	Sarcypridopsis cf *aculeata* (Cypridinae)	–	–	–	–	–	6
	Cypretta sp. (Cypridinae)	–	–	–	–	–	2
	Candoninae*	–	+	+	+	–	–
Hydracarina	*Arrenurus (Micuracarus) separatus* Smit	–	–	–	–	–	3
Oligochaeta	Phreodrillidae*	–	+	+	–	+	–
Minimum number of species		4	8	7	4	4	6

Owing to their habitat little is known of the biology of subterranean dytiscids. The fullest account is by Uéno (1957) who reports that *Morimotoa phreatica* swam weakly, walked on the substrate and did not surface for air. The adults of *Tjirtudessus* and *Nirridessus* have swimming hairs on all their legs, so presumably they need to swim at times. *Kintingka* have weak swimming hairs only on their hind legs and their small size and proportionally very strong fore and midlegs suggest an adaptation to crawling forcibly through gravel/sand – this is consistent with the hypothesis that their small size for their lineage is an adaptation to interstitial life as discussed under 'Adaptations to subterranean life'. Both species of larvae lack swimming hairs but still have urogomphi and long cerci suggesting that they are still air breathing and need to hold their urogomphi above the water with the help of the cerci. Larva form 1 have tracheae of normal appearance. Against this is the very small body size of the small form-2 larva which, like similar-sized larvae of surface species, would allow it to breathe cutaneously. It is doubtful if the much larger form-1 larva could do so.

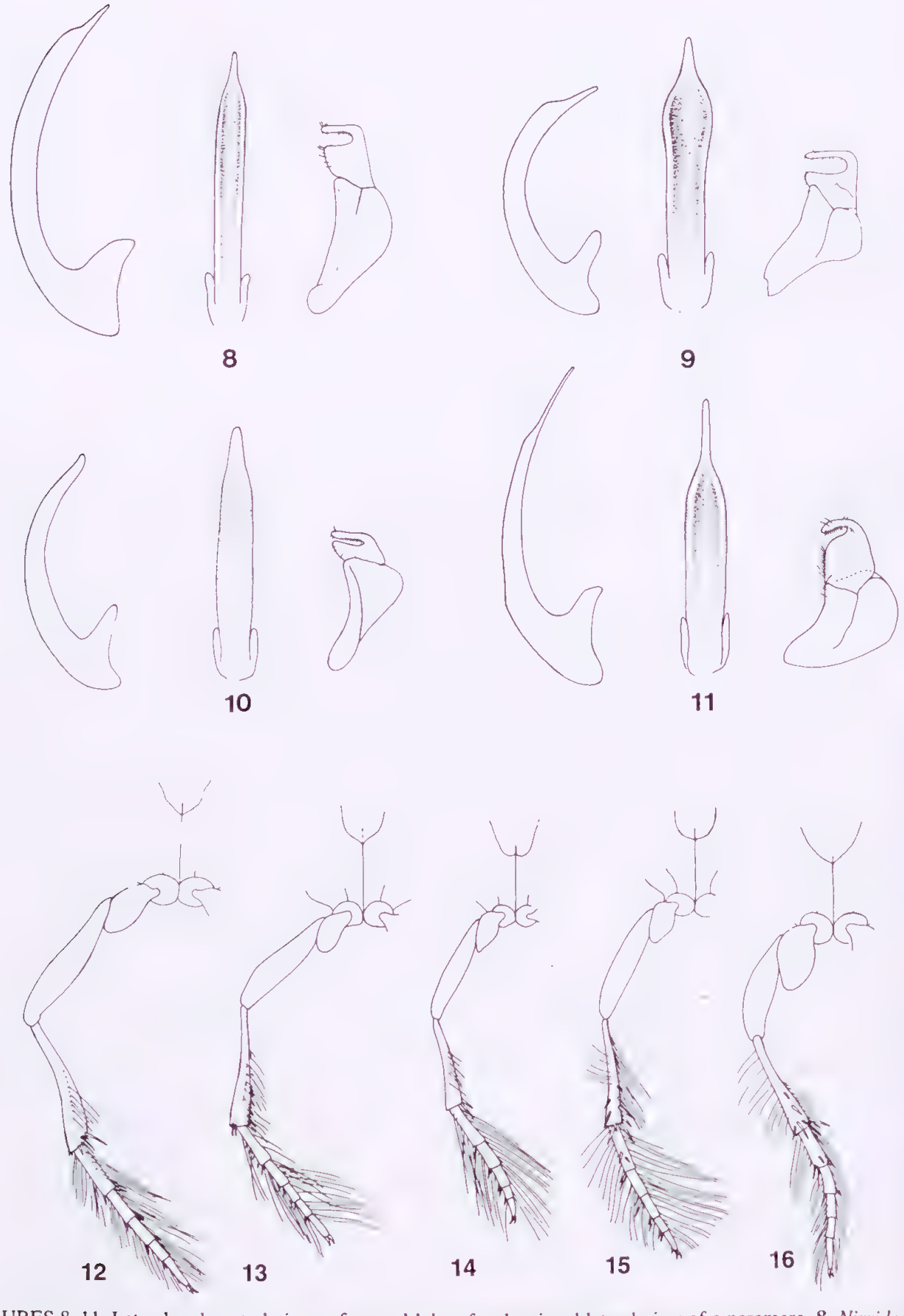
Most adult Dytiscidae are scavengers on freshly dead animals rather than active predators and live off moribund or newly dead animals. Uéno (1957) reported that *M. phreatica* fed both on living (copepod) and dead (isopod, amphipod) crustaceans and we suspect that the new genera have similar feeding habits and are feeding on the range of subterranean crustaceans including amphipods, copepods and syncarids (Table 2) which were found with them. In contrast to the adults, larval dytiscids are active predators. The large head and relatively weak body and legs of the larger larva suggest an ambush predator. The

TABLE 3. Fauna in the Windarra Calcrete Quarry piezometric field. L and W refer to *Nirridessus lapostaae* and *N. windarraensis* respectively.

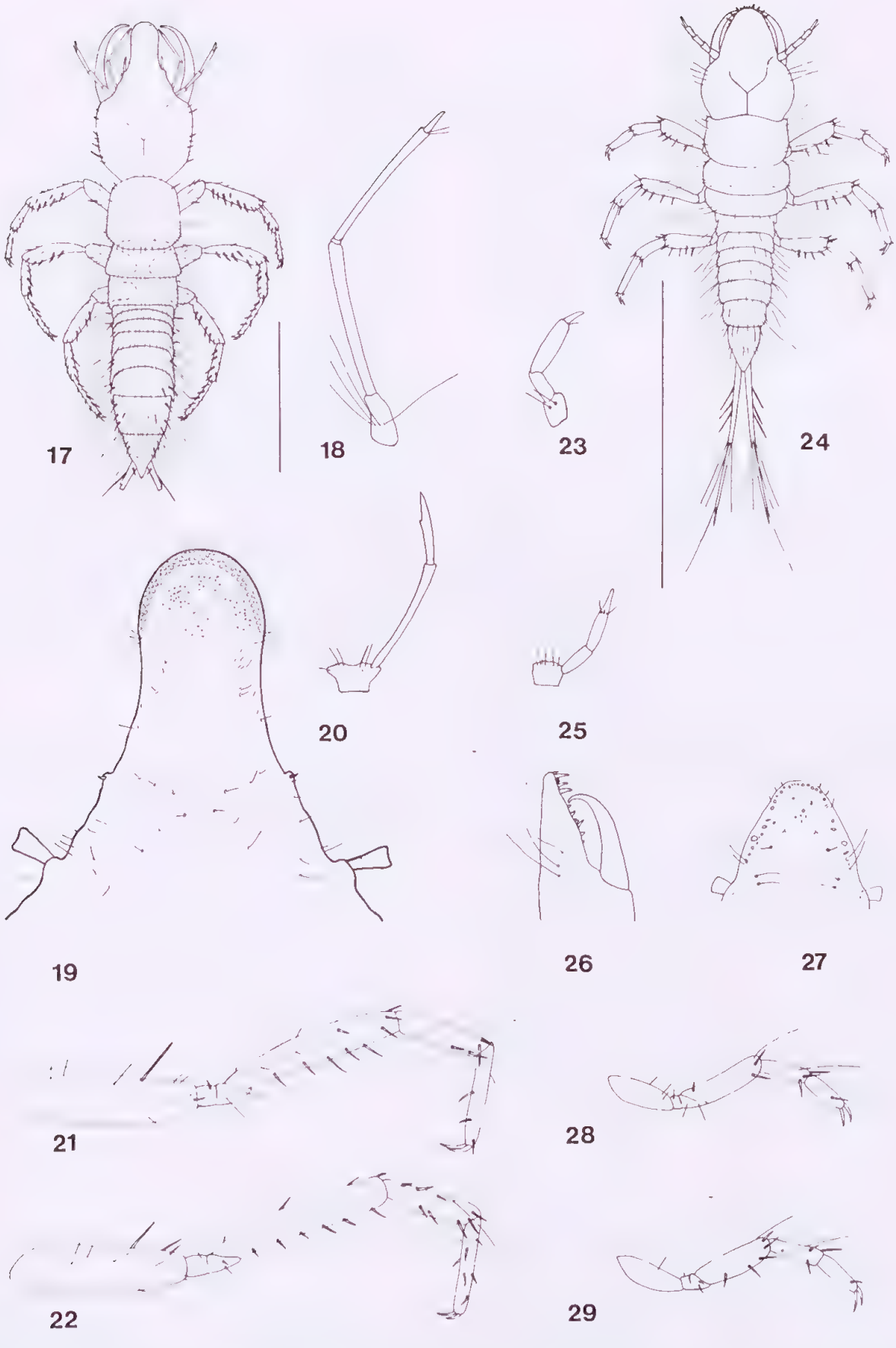
Location	Amphipoda	Copepoda Cyclopoida	Copepoda Harpacticoida	Coleoptera Dytiscidae	Oligochaeta
OP 113	+	–	–	–	–
OP 118	+	–	–	LW	–
OP 122	+	+	–	LW	+
OP 123	+	+	–	LW	–
OP 124	+	–	–	L	–



FIGURES 3–7. Dorsal views. **3**, *Nirridessus pulpa*; **4**, *N. lapostaae*; **5**, *N.windarraensis*; **6**, *Tjirtudessus eberhardi*; **7**, *Kintingka kurutjutu*. Figs 3–6 male; Fig. 7, female. Scale bar = 1mm.



FIGURES 8–11. Lateral and ventral views of central lobe of aedeagi and lateral view of a paramere. **8**, *Nirridessus windarraensis*; **9**, *N. lapostaae*; **10**, *N. pulpa*; **11**, *Tjirtudessus eberhardi*. Figures 12–16. Ventral views of hindlegs. **12**, *N. lapostaae*; **13**, *N. windarraensis*; **14**, *N. pulpa*; **15**, *T. eberhardi*; **16**, *Kintingka kurutjutu*. Drawn to approximately same size, not to scale.



FIGURES 17–22. Larva form 1. **17**, dorsal view; **18**, maxillary palpus; **19,** ventral view of nasal; **20,** labial palpus; **21**, anterior view of foreleg; **22,** posterior view of foreleg. Figures 23–29. Larva form 2. **23**, maxillary palpus; **24**, dorsal view; **25**, labial palpus; **26,** lateral view of nasal; **27,** ventral view of nasal; **28**, anterior view of foreleg; **29**, posterior view of foreleg.

strong nasal spines and strong legs of the smaller larvae suggests a much more active pursuit of a rather slippery prey.

Three of the seven adults at Paroo were taken in traps, while the remainder, and all those from Windarra, were captured in plankton nets hauled through the water column in the bores. The bore samples may not reflect the density of the fauna in the general groundwater because the bores may serve to concentrate the stygofauna owing to the steady influx of organic matter dropping down the mosly capped but not sealed bore heads.

Conservation

Groundwater calcretes mostly occur in palaeodrainage channels in arid climates where the annual rainfall is less than 200 mm and potential evaporation exceeds 3000 mm per year (Mann and Horwitz 1979). Hence, they occur widely throughout mid-latitudes of central and western Australia (map in Humphreys in press c).

The Lake Way Basin has been examined for its water potential (Sanders 1969, 1972a, 1973, 1974). Some work has been conducted on the hydrogeochemistry of aquifers in the region (Mann and Deutscher 1978; Passmore 1983). Such aquifers are actually and potentially much exploited for water resources (Environmental Protection Authority 1981), often inappropriately (Sanders 1972b). There has been and is considerable mining in the general vicinity of Wiluna and further expansion of mining activity is planned.

We need to recognise that these ecosystems may face significant risks resulting from the lowering of the water table below ecologically appropriate levels as a result of surface operations (sealing or clearing), as well as those below ground (water abstraction, mine dewatering). This is especially the case for the shallow and thin calcrete aquifer at Windarra. In addition, such processes may result in the physical modification or loss of subterranean environments through general surface slumping in floodplain calcrete aquifers resulting from the withdrawal of supporting water.

The recent discovery that these aquifers contain rich relictual faunas (Poore and Humphreys 1998; Humphreys in press c; this paper) poses challenging management issues as these aquifers often constitute the principal water supply for human activities in the arid zone.

From evolutionary and hydrological considerations it is likely that the areas occupied by these relict faunas are small and isolated, as found in the Pilbara (Poore and Humphreys 1998; W. F. Humphreys, unpublished), analogous to rainforest patches in Eastern Australia. In these conditions the threat of unwittingly harming these ancient relictual communities (discussed by Humphreys in press c) is ever present. We hope that harm can be avoided, or at least minimised, by an active program of discovery and description of these newly discovered unique faunas followed by sound management of the water resource.

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References

ARAKEL, A.V. 1996. Quaternary vadose calcretes revisited. *Journal of Australian Geology and Geophysics* **16**: 223–229.

BARNARD, L. J. and KARAMAN, G. S. 1984. Australia as a major evolutionary centre for Amphipoda (Crustacea). *Memoirs of the Australian Museum* **18**: 45–61.

BARNETT, J. C. and COMMANDER, D. P. 1985. Hydrogeology of the western Fortescue Valley, Pilbara Region. *Western Australia Geological Survey Record* 1986/8.

BRADBURY, J. H. and WILLIAMS, W. D. 1997. The amphipod (Crustacea) stygofauna of Australia: description of new taxa (Melitidae, Neoniphargidae, Paramelitidae), and a synopsis of known species. *Records of the Australian Museum* **49**: 249–341.

BISTRÖM, O. 1988. Generic review of the Bidessini

(Coleoptera, Dytiscidae). *Acta Zoologica Fennica* **184**: 1–41.

BISTRÖM, O. 1996. Taxonomic Revision of the Genus *Hydrovatus* Motschulsky (Coleoptera, Dytiscidae). *Entomologica Basiliensia* **19**: 57–584.

BOTOSANEANU, L. 1986. Ed. 'Stygofauna Mundi. A Faunistic, Distributional, and Ecological Synthesis of the World Fauna inhabiting Subterranean Waters (including the Marine Interstitial)'. E. J. Brill: Leiden.

BRANCUCCI, M. and MONTEITH, G. B. 1996. A second *Terradessus* species from Australia (Coleoptera, Dytiscidae). *Entomologica Basiliensia* **19**: 585–591.

BRUCE, N. L. and HUMPHREYS, W. F. 1993. *Haptolana pholeta* sp.nov., the first subterranean flabelliferan isopod crustacean (Cirolanidae) from Australia. *Invertebrate Taxonomy* **7**: 875–884.

CHRISTIANSEN, K. 1962. Proposition for the classification of cave animals. *Spelunca* **2**: 76–78.

CULVER, D. C., KANE, T. E. and FONG, D. W. 1995. 'Adaptation and natural selection in caves: the evolution of *Gammarus minus*'. Harvard University Press, Cambridge, Massachusetts.

DAMES and MOORE 1998. Anaconda Operations Pty Ltd, Murrin Murrin Expansion Project: Public Environmental Review. Dames and Moore Pty Ltd, Perth.

ENVIRONMENTAL PROTECTION AUTHORITY 1981. *In* 'Environmental Protection Authority, 1981. Lake Way uranium proposal by Delhi International Oil Corp and VAM Ltd Joint Venture. Report and recommendations by the Environmental Protection Authority'. *Western Australian Department of Conservation and Environmental Bulletin* **106**.

HUMPHREYS, W. F. 1993a. Cave fauna in semi-arid tropical Western Australia: a diverse relict wet-forest litter fauna. *Mémoires de Biospéologie* **20**: 105–110.

HUMPHREYS, W. F. 1993b. Stygofauna in semi-arid tropical Western Australia: a Tethyan connection? *Mémoires de Biospéologie* **20**: 111–116.

HUMPHREYS, W. F. (Ed.) 1993c. The biogeography of Cape Range, Western Australia. *Records of the Western Australian Museum Supplement* **45**: 1–248.

HUMPHREYS, W. F. in press a. The hypogean fauna of the Cape Range peninsula and Barrow Island, north-west Australia. *In* 'Ecosystems of the World, Subterranean Ecosystems'. Vol. 30. Eds H. Wilkens, D. C. Culver and W. F. Humphreys. Elsevier: Amsterdam.

HUMPHREYS, W. F., in press b. Relict faunas and their derivation. *In*, 'Ecosystems of the World, Subterranean Ecosystems'. Vol. 30. Eds H. Wilkens D. C., Culver and W. F. Humphreys. Elsevier: Amsterdam.

HUMPHREYS, W. F., in press c. Relict stygofaunas living in sea salt, karst and calcrete habitats in arid north-western Australia contain many ancient lineages. *In* 'The Other 99%. The Conservation and Biodiversity of Invertebrates.' Eds W. Ponder and D. Lunney. *Transactions of the Royal Zoological Society of New South Wales*: Mosman 2088.

JACOBSON, G. and ARAKEL, A. V. 1986. Calcrete aquifers in the Australian arid zone. *In* 'Proceedings of the International Conference on Groundwater Systems Under Stress, Brisbane'. Australian Water Resources Council. Pp. 515–523.

LARSON, D. J. 1994. *Boongurrus rivulus*, a new genus and species of water beetle (Coleoptera: Dytiscidae) from Northern Queensland, Australia. *Journal of Australian Entomological Society* **33**: 217–221.

LARSON, D. J. and STOREY, R. I. 1994. *Carabhydrus mubboonus*, a new species of rheophilic water beetle (Coleoptera: Dytiscidae) from Queensland, Australia. *The Canadian Entomologist* **126**: 895–906.

LONGLEY, G. and SPANGLER, P. J. 1977. The larva of a new subterranean water beetle, *Haideoporus texanus* (Coleoptera: Dytiscidae: Hydroporinae). *Proceedings of the Biological Society of Washington* **90**: 532–535.

MANN, A. W. and DEUTSCHER, R. L. 1978. Hydrogeochemistry of a calcrete-containing aquifer near Lake Way, Western Australia. *Journal of Hydrology* **38**: 357–377.

MARMONIER, P., VERVIER, P., GIBERT, J. and DOLE-OLIVIER, M-J. 1993. Biodiversity in ground waters. *Trends in Ecology and Evolution* **8**: 392–395.

NILSSON, A. N. 1987. A review of primary setae and pores on legs of larval Dytiscidae (Coleoptera). *Canadian Journal of Zoology* **66**: 2283–2294.

ORDISH, R. G. 1976. Two new genera and species of subterranean water beetle from New Zealand (Coleoptera: Dytiscidae). *New Zealand Journal of Zoology* **3**: 1–10.

PASSMORE, J. R. 1983. Evaluation of groundwater supplies for Lake Way Project, Wiluna. *In* 'Resources and Responsibility: ANZAAS, 53rd ANZAAS Congress, Perth, Western Australia, May 16–20, 1983, Section 3, Hydrogeological Aspects of Resource Development, Paper 217'. ANZAAS.

PEDERZANI, F. 1995. Keys to the identification of the genera and subgenera of adult Dytiscidae (sensu lato) of the world (Coleoptera; Dytiscidae). *Atti Accademia Roveretana Agiati* **244**(1994): 5–83.

POORE, G. C. B. and HUMPHREYS, W. F. 1992. First record of Thermosbaenacea (Crustacea) from the Southern Hemisphere: a new species from a cave in tropical Western Australia. *Invertebrate Taxonomy* **6**: 719–725.

POORE, G. C. B. and HUMPHREYS, W. F. 1998. The first record of the Spelaeogriphacea (Crustacea) from Australasia: a new genus and species from an aquifer

in the arid Pilbara of Western Australia. *Crustaceana* **71**: 721–742.

SANDERS, C. C. 1969. Hydrogeological reconnaissance of calcrete areas in the East Murchison and Mt. Margaret Goldfields. *Western Australian Geological Survey Annual Report 1968*, 14–17.

SANDERS, C. C. 1972a. Hydrogeology of the Paroo calcrete and surrounding areas, Wiluna District, Western Australia. *Western Australian Geological Survey Record* 1972/7.

SANDERS, C. C. 1972b. Desert farms area, Wiluna. Preliminary appraisal of salinity and groundwater movement. *Western Australia Geological Survey, Record* 1972/18.

SANDERS, C. C. 1973. Hydrogeology of a calcrete deposit on Paroo Station, Wiluna, and surrounding areas. *Western Australian Geological Survey Annual Report* 1972, 15–26.

SANDERS, C. C. 1974. Calcrete in Western Australia. *Western Australian Geological Survey Annual Report* 1973, 12–14.

SMRZ, J. 1983. Morphological adaptations of sensory organs and wings in subterranean water beetles (Coleoptera, Dytiscidae). *Acta entomologica Bohemoslovaca* **80**: 246–255.

SPANGLER, P. J. 1986. Insecta: Coleoptera. *In* 'Stygofauna. A Faunistic, Distributional, and Ecological Synthesis of the World Fauna inhabiting Subterranean Waters (Including the Marine Interstitial)'. Ed. L. Botosaneanu. E. J. Brill: Leiden.

SPANGLER, P. J. 1996. Four new stygobiontic beetles (Coleoptera: Dytiscidae; Noteridae; Elmidae). *Insecta Mundi* **10**: 241–259.

SPANGLER, P. J. and BARR, C. B. 1995. A new genus and species of stygobiontic dytiscid beetle, *Comaldessus stygius* (Coleoptera: Dytiscidae: Bidessini) from Comal Springs, Texas. *Insecta Mundi* **9**: 301–308.

UENO, S.-I. 1957. Blind aquatic beetles of Japan, with some accounts of the fauna of Japanese subterranean waters. *Archive für Hydrobiologie* **53**: 250–296.

UENO, S.-I. 1996. New Phreatobiontic Beetles (Coleoptera, Phreatodytidae and Dytiscidae) from Japan. *Journal of the Speleological Society of Japan* **21**: 56.

WATTS, C. H. S. 1978. A revision of Australian Dytiscidae (Coleoptera). *Australian Journal of Zoology (Supplementary Series)* **57**: 1–166.

WEWALKA, G. and BISTRÖM, O. 1998. *Glareadessus* gen. n. with descriptions of two new species from the Persian Gulf Region (Coleoptera: Dytiscidae). *Koleopterologische Rundschau* **68**: 59–63.

WILSON, G. D. F. and KEABLE, S. J. in press. A new genus of phreatoicidean isopod (Crustacea) from the North Kimberley Region, Western Australia. *Zoological Journal of the Linnean Society, London.*

WOLFE, G. W. 1985. A phylogenetic analysis of plesiotypic hydroporine lineages with an emphasis on *Laccornis* Des Gozis (Coleoptera; Dytiscidae). *Proceedings of the Academy of Natural Sciences of Philadelphia* **137**: 132–155.

WOLFE, G. W. 1987. A phylogenetic investigation of *Hydrovatus*, Methlini and other plesiotypic hydroporines (Coleoptera: Dytiscidae). *Psyche* **95**: 327–344.

YAGER, J. and HUMPHREYS, W. F. 1996. *Lasionectes exleyi*, sp. nov., the first remipede crustacean recorded from Australia and the Indian Ocean, with a key to the world species. *Invertebrate Taxonomy* **10**: 171–187.

YOUNG, F. N. and LONGLEY, G. 1976. A new subterranean aquatic beetle from Texas (Coleoptera: Dytiscidae-Hydroporinae). *Annals of the Entomological Society of America* **69**: 787–792.

NEW SPECIES OF *ANTIPATHES* AND *PARANTIPATHES* (CNIDARIA: ANTHOZOA: ANTIPATHARIA) FROM COASTAL WATERS OF SOUTH AUSTRALIA AND TASMANIA

DENNIS M. OPRESKO

OPRESKO, D. M. 1999. New Species of *Antipathes* and *Parantipathes* (Cnidaria: Anthozoa: Antipatharia) from Coastal Waters of South Australia and Tasmania. *Records of the South Australian Museum* **32**(2): 143-154.

One new species of the genus *Antipathes* and two new species of the genus *Parantipathes* are described from the coastal waters of South Australia. *Antipathes antrocrada* sp. nov. resembles *A. bifaria* Brook, 1889 and *A. lata* Silberfeld, 1920, but differs from these two species in having less crowded polyps, larger pinnular spines, and thinner pinnules that are more spreading and not as strongly directed distally. *Parantipathes helicosticha* sp. nov. differs from the closely related *P. tetrasticha* (Pourtalès, 1868) by having shorter pinnules, larger spines and smaller polyps. *Parantipathes triadocrada* sp. nov. is similar to *P. columnaris* (Duchassaing, 1870), but is branched to a greater degree, does not have a reticulated worm run along the stem or branches, is extensively subpinnulated, and rarely has more than three pinnules or subpinnules in each verticil-like cluster.

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Introduction

This is the second in a series of papers dealing with the antipatharian fauna of the waters off southern Australia and Tasmania. Species of the genus *Leiopathes* have been previously described (Opresko 1999). The holotypes and paratypes of the new species are deposited in the South Australian Museum (SAM), Adelaide, S. Australia. Schizotypes are deposited in the U.S. National Museum of Natural History (USNM) in Washington, DC.

Taxonomic Section

Order Antipatharia Milne Edwards, 1857

Family ANTIPATHIDAE Ehrenberg, 1834

Genus *Antipathes* Pallas, 1766

Remarks

In 1834 Ehrenberg used the name Antipathina for a family-level taxon in the Order Scleropoda of the Class Bryozoa. Although it is likely that Ehrenberg was actually referring to a bryozoan that was encrusting an antipatharian axis, his usage has priority over subsequent designations in which the family was more correctly identified as anthozoan corals (see Gray 1840 and Dana 1846). Note: if the taxonomic revision of van Pesch (1914) is followed, over 150 nominal species must be assigned to the genus *Antipathes*. This arrangement totally obscures the natural affinities of the various species complexes in the genus. Because a revision of the order focusing on the identification of these species complexes and the establishment of new genera and/or subgenera is currently being undertaken, diagnoses and keys for the currently recognized genera will not be presented here.

Antipathes antrocrada sp. nov.

(Figs 1–3)

Diagnosis

Corallum branched and pinnulated. Primary pinnules on branches and branchlets arranged alternately, generally bilaterally, and inclined distally. Secondary pinnules arranged uniserially near base of primaries, projecting out of plane containing primary pinnules, and inclined distally relative to primary pinnule on which they arise. Distal secondary pinnules bilateral, with narrow interior angle; interior angle generally increasing with increasing size of branchlets. Spines on pinnules simple, conical to subcylindrical with an acute apex; inclined distally; generally 0.10 to 0.14 mm tall on highest order pinnules, increasing to about 0.2 mm on lower order pinnules and

FIGURE 1. *Antipathes antrocrada* sp. nov., holotype, SAM H-746, entire corallum, height about 22 cm.

branches; maximum size about 0.3 mm. Polyps usually 0.8–0.9 mm in transverse diameter; arranged uniserially, with 9–10 polyps per centimetre.

Description of Holotype

The holotype (SAM H-746; Fig. 1) may only be a branch from a larger colony; a basal plate is not present. It is about 25 cm tall and 12 cm wide and the 'stem' or primary branch is 3.0 x 4.5 mm in diameter at its basal end. Several large branches come off the 'stem' in an irregular fashion and at irregular angles, and they bear smaller branches. Both branches and branchlets are curved to varying degrees, and all are pinnulate. The arrangement of the pinnules and subpinnules is

FIGURE 2. *Antipathes antrocrada* sp. nov., holotype, SAM H-746. **A**, outer edge of corallum showing the arrangement of the pinnules, approx. x 1.2. **B**, pinnules with polyps, approx. x 3.0.

not perfectly regular throughout the colony. In general, primary pinnules on the branches and branchlets have the appearance of being arranged alternately in two nearly opposite rows (Fig. 2A). The primary pinnules are mostly 1–2.5 cm long and 0.1–0.15 mm in diameter at their base excluding spines (0.2–0.3 mm wide including spines). They are spaced 3–5 mm apart in each lateral row and within each row they arise anterolaterally such that the interior angle formed by the two rows is 60–90° at the point of insertion on the branch. However, the more distal sections of the primary pinnules are recurved such that two pinnular rows have the general appearance of being nearly opposite one another. The primary pinnules are also inclined distally (distal angle 45–70°). The primary pinnules, in turn, often have a series of 3–6 secondary pinnules (Fig. 2A), mostly 4–5 mm long and 0.14 mm in diameter (up to 10 mm long and 0.16 mm in diameter), and spaced 2–4 mm apart. The lowest secondary pinnule is 4–6 mm from the base or point of insertion of the primary pinnule. The lowermost secondary pinnules on each primary are arranged uniserially, inclined distally, and tend to lie in a plane at nearly right angles to the plane containing the primary pinnules. Pinnules longer than 1.5–2 cm become branchlets with the distal-most secondary pinnules becoming bilateral and alternating, usually with a very narrow interior angle. Thus, over the entire corallum, and even on the larger branches, there is a pattern in which the pinnules go from a uniserial arrangement proximally to a bilateral arrangement distally, and for the interior angle formed by the two lateral rows of pinnules to increase with increasing length and thickness of the branchlets.

The skeletal spines (Figs 3A–3C) are simple, conical to subcylindrical, with a smooth to slightly coarse distal surface and an acute apex. The polypar spines are larger than the abpolypar spines; both tend to be inclined distally. Polypar spines on the lower portions of the higher order pinnules (axial diameter 0.1–0.15 mm) are generally 0.10 to 0.14 mm tall (distance from the midpoint of the base to the apex); the abpolypar spines are 0.08–0.10 mm. On the pinnules the spines are arranged in axial rows, 4–7 of which are visible in lateral view (excluding rows in which spines are only partially visible). The distance between adjacent spines in each row ranges from 0.08–0.18 mm, and there are 6–8 spines per millimetre in each row. The spines increase in number and size and become more acicular with increasing thickness of the axis; on pinnules or branchlets having a diameter of 0.2–

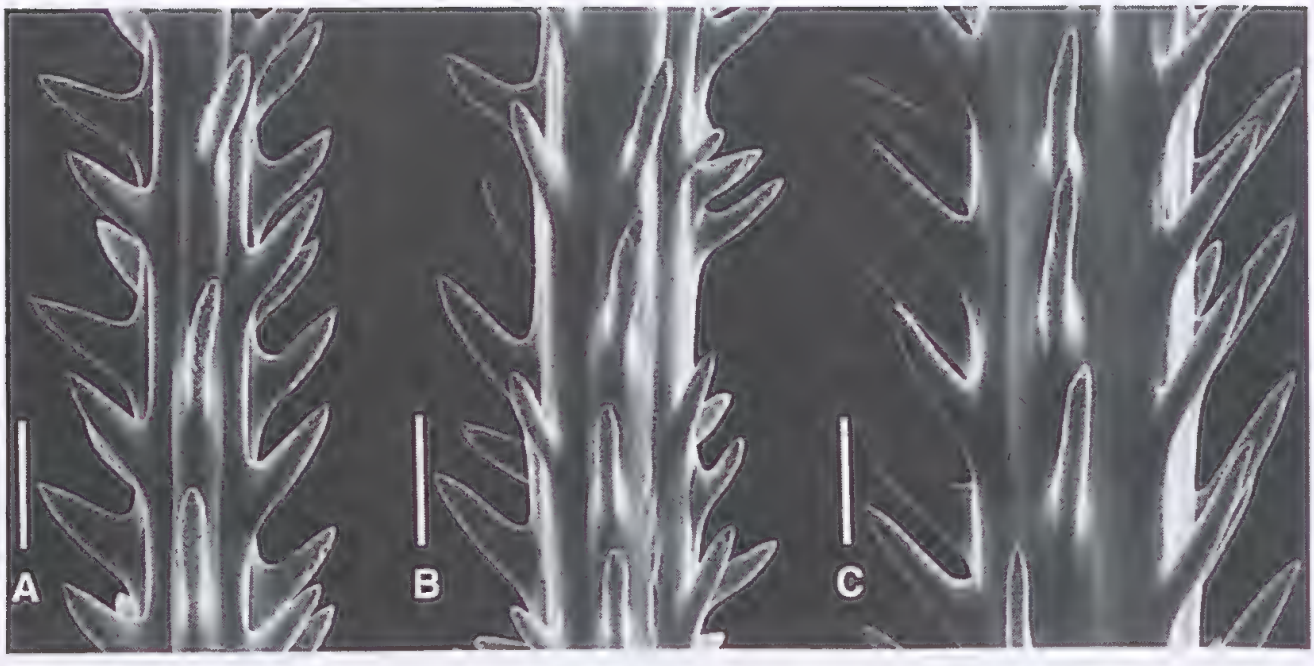

FIGURE 3. *Antipathes antrocrada* sp. nov., scanning electron micrographs of holotype, SAM H-746. **A**, Spines on pinnule 0.09 mm in diameter. **B**, spines on pinnule 0.12 mm in diameter. **C**, spines on branchlet 0.19 mm in diameter. Scale bars 0.1 mm.

0.3 mm the spines are 0.12–0.18 mm tall; on larger branches (0.3–0.4 mm in diameter) they are up to 0.22 mm tall. The spines on the lowest part of the 'stem' (diameter 3.2 mm) are mostly simple, 0.2–0.24 mm tall (maximum about 0.32 mm) and 0.02–0.03 mm in diameter; a few are forked at the apex.

The polyps (Fig. 2B) are distributed uniserially and generally restricted to the pinnulated side of the branches and branchlets. On the primary pinnules the polyps are found on the side having the subpinnules; they are at right angles to the direction of the branch on which the pinnules occur, or they can be offset somewhat towards the upper side of the pinnules relative to the direction of the branch. Where the interior angle of the pinnules is narrow, the polyps in opposing lateral pinnular rows face towards each other. On the secondary pinnules the polyps are positioned laterally (at right angles) relative to the direction of the primary pinnule, or they are offset, to varying degrees, towards the upper side (in the direction of the distal end of the primary pinnule). The polyps range in size from 0.6 mm to 0.9 mm (transverse diameter as measured from the distal side of base of distal lateral tentacles to the proximal side of the base of the proximal lateral tentacles), but most are 0.8–0.9 mm. The interpolypar space ranges from 0.1 to 0.2 mm, the smaller space usually found between two larger polyps. On average, there are 9–11 polyps per centimetre. The mouth is often slit-shaped and elongated along the sagittal axis and surrounded by a wide oral disc, and the tentacles are up to 0.3 mm long (in the alcohol-preserved material). Polyps are restricted to one of the two wider sides of the stem, but they are more scattered and not in a single series.

Discussion

The paratype (SAM H-745) shows the same general growth form as the holotype; however, in this specimen there is more variability in the interior angle formed by the two rows of pinnules, and many pinnules are inclined distally to a greater degree than those in the holotype. Furthermore, the lowermost (most basal) secondary pinnules often occur further away (i.e., up to 10 mm) from the base of the primary pinnule than those in the holotype.

Comparisons

Antipathes antrocrada sp. nov. resembles *A. bifaria* Brook, 1889 and *A. lata* Silberfeld, 1909. In all of these species the corallum is irregularly branched and pinnulate, and the pinnules are arranged uniserially to biserially. However, based on the descriptions given by Brook (1889) and Silberfeld (1909), the pinnules in *A. bifaria* and *A. lata* are more strongly directed distally (distal

angle less than 45°), and the interior angle formed by the two pinnular rows is much narrower than the condition occurring in *A. antrocrada*. In addition, the pinnules in these species appear to be thicker than those in *A. antrocrada* [as suggested by the illustration given by Silberfeld (1909)], but the spines on the pinnules may be slightly smaller (0.1 mm vs. 0.1–0.14 mm in *A. antrocrada*). The polyps in *A. lata* appear to be more crowded; Silberfeld (1909) reported a polyp density of 12 per centimetre, whereas the polyp density is, on average, 9–11 per centimetre in *A. antrocrada*. Polyps were not present in the type specimen of *A. bifaria* described by Brook (1889).

Etymology

The specific name is derived from the Latin '*antrorsus*' (directed forward and upward) and '*crada*' (twig), in reference to the curving of the pinnulated branchlets.

Material Examined

Australia, Great Australian Bight, approx. 100 nautical miles (185.2 km) SSW of Eucla, 33°16'S, 128°09'E, 170 m, R/V *Comet*, 14 January 1989, coll: W. Zeidler and K. Gowlett-Holmes (holotype, SAM H-746; schizoholotype, USNM 99415). Great Australian Bight, approx. 100 nautical miles (185.2 km) SSW of Eucla, 33°16'S, 128°16'E, 190 m, R/V *Comet*, 14 January 1989, coll: W. Zeidler and K. Gowlett-Holmes (paratype, SAM H-745; schizoparatype, USNM 99413).

Distribution

The species is known only from waters off South Australia at depths of 170–190 m.

Genus *Parantipathes* Brook, 1889

Parantipathes helicosticha sp. nov.

(Figs 4–6)

Diagnosis

Corallum sparsely branched and pinnulate. Pinnules simple, arranged biserially in 6–8 (rarely 9 or 10) rows, and in semi-spiral groups of 3–4 (rarely 5) pinnules each. Pinnules extending at nearly right angles to the direction of stem or branch on which they occur. Spines simple, smooth, acute, inclined distally; 0.10–0.20 mm from centre of base to apex. Spines arranged in axial rows, three or four of which are visible in lateral view; spaced 0.3–0.8 mm apart in each row; with 2–3.5 spines per millimetre. Polyps transversely elongated, 1.6–1.8 mm in diameter from proximal edge of proximal tentacles to distal edge of distal tentacles. Polyps arranged uniserially on upper side of pinnules, facing towards the distal end of the stem or branches. Interpolypar space about 0.6 mm, resulting in four polyps per centimetre.

Description of Holotype

The holotype (SAM H-903) is a nearly complete colony with basal plate and polyps intact (Fig. 4). It is about 55 cm tall and 27 cm wide and has a basal stem diameter of 3.5 x 4.5 mm. It is very laxly branched (only about 14 branches in all), with the branches spaced at varying distances, some only several millimetres apart, others several centimetres apart. The branches are long; the largest is about 33 cm and has a basal diameter of about 2 mm. At their point of origin, the branches project at nearly a right angle to the stem or lower order branch from which they arise; they are straight or irregularly curved over most of their course. Both the stem and branches have a columnar growth form due to the presence of multiple rows of simple elongate pinnules that lie perpendicular to the direction of the stem or branch from which they arise (i.e., distal angle about 90°). The rows of pinnules are arranged biserially, usually with an equal number on each side (Fig. 5). The most common condition is three or four rows on each side, but rarely there may be four on one side and up to five on the other. The pinnules are also arranged in alternating semi-spiral groups along the length of the branches, each group consisting of one member from each row. The pinnules in each semi-spiral group on one side of the axis follow a clockwise direction, those on the opposite side follow a counterclockwise pattern. The semi-spirals on both sides thus appear to follow an ascending pattern when viewed from one side of the corallum and a descending pattern when viewed from the opposite side. Each semi-spiral covers an axial distance of about 2 mm and often the most distal pinnule of one semi-spiral is at about the same level as the most basal pinnule of the next group on the same side. In some cases, the lowest or highest pinnule in each semispiral is located near the middle of the front or back of the axis. There are usually four semi-spiral groups per centimetre in each series. The pinnules are simple, 1.5–2 cm long and about 0.2 mm in diameter at their base. The pinnules are straight or curved upward slightly.

FIGURE 4. *Parantipathes helicosticha* sp. nov., holotype, SAM H-903, entire corallum, height about 55 cm.

The skeletal spines (Fig. 6) are simple (very rarely forked), smooth, conical to horn-shaped, very acute, and inclined distally, particularly on the mid to distal part of the pinnules. They are about 0.10 mm tall on the basal portion of the pinnules, 0.14–0.16 mm tall along the mid portion and up to 0.20 mm tall on the distal portion. The abpolypar spines are usually 0.02–0.04 mm smaller than the polypar spines, but they are sometimes larger. On the pinnules the spines are arranged in axial rows, 3–4 of which are visible in lateral view (excluding rows in which spines are only partially visible). The distance between adjacent spines in each row is variable (0.3–0.8 mm), but on average there are 2.0–3.5 spines per millimetre in each row. Spines are reduced in size on the stem and branches. On the stem the spines are no more than about 0.06 mm tall.

FIGURE 5. *Parantipathes helicosticha* sp. nov., holotype, SAM H-903; section of corallum showing arrangement of pinnules and polyps, approx. x 4.

The polyps (Fig. 5) on the pinnules are arranged uniserially on the upper side, facing towards the distal end of the branch on which they occur. They are mostly 1.6–1.8 mm in transverse diameter, as measured from the distal edge of the distal lateral tentacles to the proximal edge of the proximal lateral tentacles. The interpolypar space is 0.6 mm, and there are usually 4 polyps per centimetre.

Discussion

Paratypes SAM H-904 and H-901 are similar to the holotype in the growth form of the corallum, and in the size, number, and arrangement of the pinnules. The remaining paratype (SAM H-752) is more densely branched than the holotype and its pinnules are less regularly arranged, more often in semi-spiral groups of 2–3 (4 on the thicker branches), and the pinnules are spaced further apart. Each semi-spiral group takes up as much as 3 mm; therefore, there are only three groups per centimetre on each side as compared to 4 in the holotype. The spines are also slightly smaller than in the other specimens. Analysis of additional specimens may show that this specimen represents a species distinct from *P. helicosticha*.

Comparisons

Parantipathes helicosticha, sp. nov. resembles *P. larix* (Esper, 1790) and *P. tetrasticha* (Pourtalès, 1868) in the general

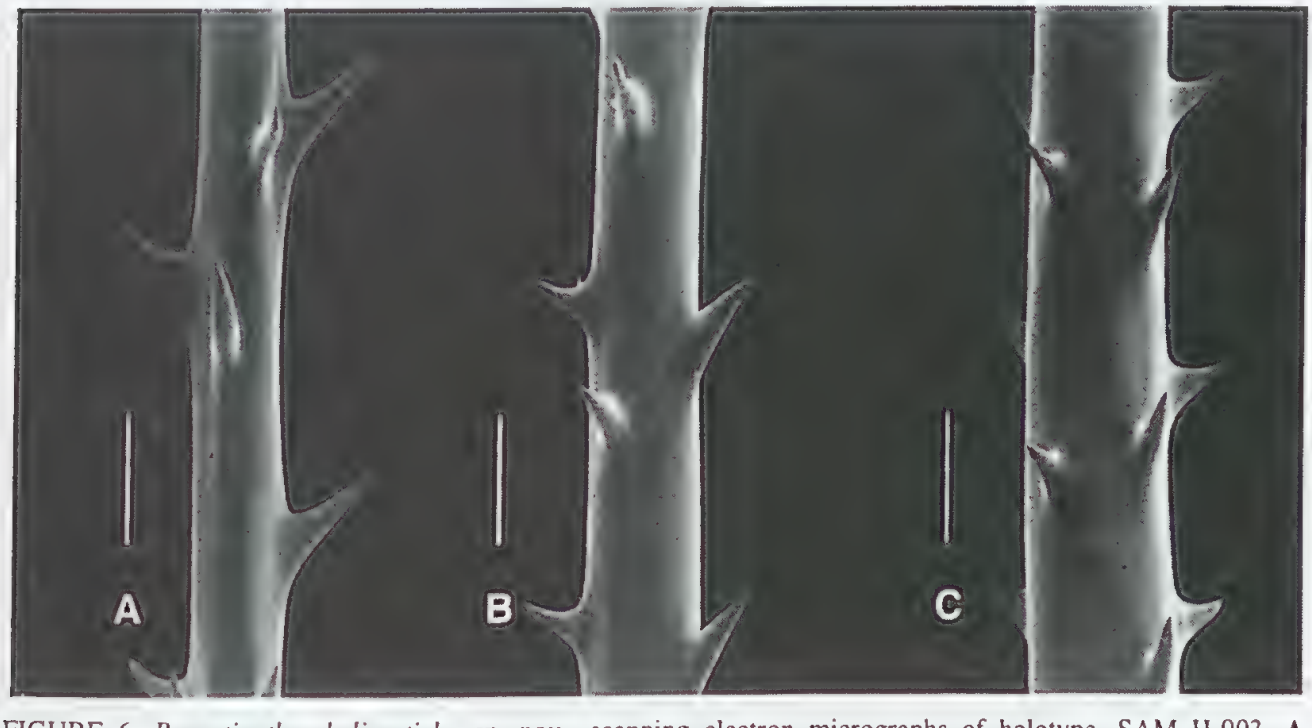

FIGURE 6. *Parantipathes helicosticha* sp. nov., scanning electron micrographs of holotype, SAM H-903. **A**, Spines near tip of pinnule 0.13 mm in diameter. **B**, spines on pinnule 0.16 mm in diameter. **C**, spines near base of pinnule 0.2 mm in diameter. Scale bars 0.2 mm.

appearance of the corallum, but differs from these species in the length or number of rows of pinnules or in the size of the spines. *P. larix* typically has only 6 rows of simple pinnules, and depending on the size of the corallum, the pinnules can be 3.5 cm to as much as 12 cm in length (Brook 1889). The spines of *P. larix* are much smaller than those in *P. helicosticha*; only 0.06–0.09 mm, as estimated from the illustration given by Brook (1889), and the polyps are slightly longer, about 2.0 mm in transverse diameter (Brook 1889). In *P. tetrasticha*, there can be up to 8 rows of pinnules, as in *P. helicosticha*, but the pinnules are longer (up to 4 cm), the spines are shorter (0.04–0.08 mm), and the polyps are more transversely elongated (2.5 mm). Both *P. larix* and *P. tetrasticha* were originally described from the Atlantic. *Parantipathes larix* has also been reported from the Pacific (van Pesch 1914). However, van Pesch's description more closely resembles that of *P. helicosticha* than *P. larix*.

Etymology

The specific name is derived from the Latin '*helico*' (helix) and Greek '*sticha*' (twig) in reference to the arrangment of the pinnules in a quasi helical pattern.

Material Examined

Australia, approx.125 nautical miles (231 km) E of Cape Arid, W. Australia, 33°03'S, 125°31'E, 1011–1020 m, F/V Adelaide Pearl, K. Gowlett-Holmes, K. Olsson and M. Cameron, 31 July 1988, (holotype, SAM H-903; schizoholotype, USNM 99401). Approx. 125 nautical miles (231 km) S of Eucla, S. Australia, 33°45'S, 129°17'E, 999–1110 m, F/V Adelaide Pearl, K. Gowlett-Holmes, K. Olsson and M. Cameron, 1 August 1988 (paratype, SAM H-904: schizoparatype, USNM 99400). Approx. 46 nautical miles (85 km) SE of SE Cape, Tasmania, 44°14.8'S, 147°27.5'E, 1080–1130 m, F/V Belinda, K.L. Gowlett-Holmes, 9 February 1992 (paratype, SAM H-901; schizoparatype, USNM 99412). Great Australian Bight, approx. 130 nautical miles (240.8 km) SSW of Cape Adieu, 34°06'S, 131°20'E, 1124–1131 m, F/V Longa III, K. Gowlett-Holmes, 15 December 1989 (paratype, SAM H-752; schizoparatype, USNM 99414).

Distribution

The species is known only from the waters off Tasmania and South Australia at depths of 999 to 1130 m.

***Parantipathes triadocrada* sp. nov.**
(Figs 7–9)

Diagnosis

Corallum sparsely branched, but densely pinnulate. Primary pinnules arranged in three irregular axial rows, two lateral and one posterior. Lateral primary pinnules more complexly subpinnulate than posterior primary pinnules. Pinnules and subpinnules (six or more orders) also grouped together in clusters (pseudo-verticils) containing one pinnule from each row. Pinnules and subpinnules adhering. Spines simple, conical, smooth, with acute to rounded apex; usually 0.06–0.08 mm from centre of base to apex. Spines on pinnules and subpinnules arranged in axial rows; up to 6–7 rows visible in lateral view. Spines 0.16–0.30 mm apart in each row, with 5–6 spines per millimetre, on average. Polyps not more than 1.2 mm in transverse diameter from proximal side of proximal lateral tentacles to distal side of distal lateral tentacles. Polyps arranged uniserially on upper or anterolateral sides of pinnules and subpinnules; with 7–8 polyps per centimetre.

Description of Holotype

The holotype (SAM H-908; Fig. 7) is about 22 cm tall and 12 cm wide and has at its basal end a reticulated skeletal structure formed by the irregular cross-linking of adjacent branches by thick branchlets. This part of the colony has a stem-like branch about 2 mm in diameter. Several branches 10–20 cm in length originate along this 'stem' and extend vertically, one becoming fused apically with pinnules of the stem. Both the stem and major branches have a columnar growth form due to the presence of pinnules along their length. Although the pinnules can occur singly and in pairs, the most common arrangement is in three irregular vertical rows and also in clusters each containing three (very rarely four) members. Two of the vertical rows are bilateral and the third is on the posterior side of the axis. The pinnules in the two lateral rows are usually much more higher developed (complexly subpinnulate) than those in the posterior row (Fig. 8A); consequently, the stem and individual branches have a somewhat bilateral structure. The clusters of pinnules consist of one member of each row arising from nearly the same location on the axis; however, the members of a group rarely arise at exactly the same point. Instead, they are separated by intervals of 0.1–0.3 mm (Fig. 8B). Therefore, the clusters might best be referred to as pseudo-verticils. The arrangement of the pinnules within each pseudo-

FIGURE 7. *Parantipathes triadocrada* sp. nov., holotype, SAM H-908, height about 22 cm.

verticil is irregular; a spiral or helical pattern not being apparent. The pseudo-verticils are spaced, on average, about 3 mm apart, but the distance can range from 2.5 to 4.5 mm. On some parts of the corallum the pseudo-verticils are incomplete due to the absence of one or even two members, and consequently, the pinnules and subpinnules are spaced irregularly along the axis.

The lateral primary pinnules on the stem and branches have as many as six orders of subpinnnules; in contrast, the posterior primary pinnules have relatively few subpinnules (Fig. 8A). The subpinnules develop in the same manner as the primary pinnules, usually in pseudo-verticils of three, spaced about 3 mm apart. Any one or more of the subpinnules can, in turn, have similar subpinnules, and this pattern can be repeated over several higher orders of

FIGURE 8. *Parantipathes triadocrada* sp. nov., holotype, SAM H-908. **A**, cross section of branch showing arrangement of pinnules, approx. x 1.7. **B**, lateral view of clusters of pinnules, approx. x 3.5. **C**, pinnules with polyps, approx. x 5.

subpinnules. Although many exceptions occur, pinnules less than 1 cm long are likely to have only one order of subpinnules (and sometimes only one or a bilateral pair, rather than three); those about 2 cm long often have 1 or 2 orders of subpinnules; those 3 cm long have four or five; and those 4 cm long have as many as 6 orders. The subpinnules do not develop to the same extent from pinnule to pinnule; therefore the pattern of subpinnulation is not symmetrical. The largest unpinnulated pinnules or subpinnules are rarely more than about 7 mm in length and have a basal diameter of 0.14–0.16 mm (excluding spines). The pinnules and subpinnules arise from the lower order ramifications at nearly a right angle, but in most cases they curve upward towards the distal end of the stem or branch on which they occur. Overall, the apparent distal angle is 45–60°. Fusions of overlapping pinnules and subpinnules occur frequently and as a result, the lateral sides of the stem and branches (and also the anterior side in some places) form a dense mass of anastomosing subpinnules. Subpinnules of some adjacent branches are also fused together.

The skeletal spines (Fig. 9) are simple, smooth, and conical with an acute to rounded apex. They are mostly subequal in size around the circumference of the axis, although in places they can be slightly larger to twice as tall on one side. Spines on the pinnules and subpinnules are usually 0.06–0.08 mm tall from the midpoint of the base to the apex; a few near the base of the larger pinnules (diameter 0.14–0.16 mm) reach a size of 0.10–0.12 mm. The majority of spines project at right angles to the axis; some are inclined distally, particularly those near the distal end of the pinnule. The spines are arranged in axial rows with 3–4 rows visible in lateral view (including only rows in which the base of the spines can be seen). However, on some pinnules, and primarily near the base of the pinnules, as many as 6–7 rows are visible. The distance between adjacent spines in each row varies from about 0.16 to 0.30 mm; on average there are 5–6 spines per millimetre in each row. Although the distribution and spacing of the spines is quite regular on many pinnules and subpinnules, the pattern becomes less regular near the base of the pinnules, with new spines developing between the rows. There are only a few scattered spines on the larger branches at the base of the corallum, some of these are relatively narrow and acicular, but few are more than 0.06 mm tall.

The polyps (Fig. 8C) on the subpinnules and pinnules are distributed uniserially on the upper or anterolateral sides of axis, thereby facing toward the distal end of the branch on which the pinnules occur. Because the pinnulation is more strongly developed on one side of the axis, there is a distinct polypar and abpolyar side of the

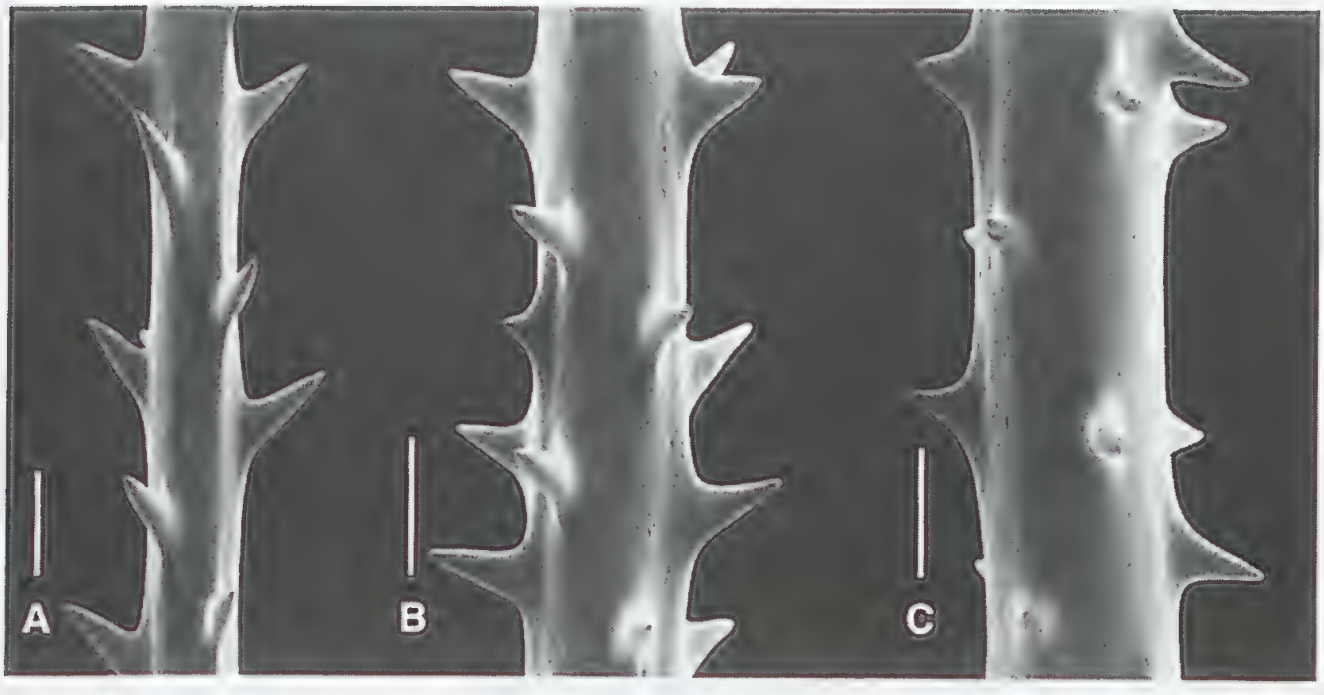

FIGURE 9. *Parantipathes triadocrada* sp. nov., scanning electron micrographs of holotype, SAM H-908. **A**, Spines near distal end of pinnule 0.08 mm in diameter. **B**, spines on middle of pinnule 0.1 mm in diameter. **C**, spines on pinnule 0.15 mm in diameter. Scale bars 0.1 mm.

corallum when viewed from above (Fig. 8A). The polyps are 0.8–1.1 mm in transverse diameter, as measured from the distal side of the base of the distal lateral tentacles to the proximal side of the base of the proximal lateral tentacles, and the interpolypar space is 0.3–0.4 mm. Seven to 8 polyps occur along one centimetre of axis. The mouth is often slit-shaped and elongated along the sagittal axis, and the tentacles are up to 0.3 mm long (in the alcohol-preserved material). Some polyps appear very elongated along the transverse axis such that transverse diameter is about three times longer than the sagittal diameter (e.g., 0.8 mm vs. 0.25 mm).

Discussion

A second specimen collected at the same station as the holotype is about 25 cm tall and 6 cm wide (SAM H-986). At its basal end (as well as at several points higher up on the corallum) it has a reticulated skeletal structure similar to that seen in the holotype. This colony and the other two paratypes exhibit the same general growth form as the holotype, with the major branches directed vertically and with numerous anastomosing pinnules and subpinnules. Young colonies are likely to have a simple corallum with few if any branches. In one of the two paratypes (which is broken in three pieces) a well-defined stem is present which, just above the holdfast, is 4.5 x 5.5 mm in diameter. As in the holotype, the axis of the stem and major branches is compressed laterally (oblong in cross section) such that the widest diameter is at right angles to the plane formed by the lateral pinnules.

Comparisons

This species resembles *Parantipathes columnaris* (Duchassaing, 1870) in having the pinnules and subpinnules arranged in pseudo-verticils. However, in *P. columnaris* the corallum is usually monopodial, always has reticulated worm run along the stem, has fewer orders of subpinnules, and usually more than three subpinnules in each pseudo-verticil.

Several species currently placed in the genus *Parantipathes*, including *P. columnaris* (Duchassaing, 1870), *P. tenuispina* Silberfeld, 1909, and *P. cylindrica* Brook, 1889, differ from the type species *P. larix* (Esper, 1790) in having polyps that are not much more then 1.0 mm in transverse diameter. These species also form a natural assemblage united by the tendency of parts of the corallum to anastomose. These species may also have affinities to several flabellate species (i.e., *Tylopathes crispa* Brook, 1889 and *Antipathella contorta* Brook, 1889) which have similar sized polyps and anastomosing branches and branchlets. Further study may show that these species merit separate taxonomic recognition.

Etymology

The specific name is derived from the Latin '*triado*' (in groups of three) and '*crada*' (twig) in reference to the arrangement of the pinnules and subpinnules into pseudo-verticillate clusters of three.

Material Examined

Off Tasmania, approx. 46.5 nautical miles (86 km) SSE of South East Cape, 44°22.7'S, 147°07.3'E, 1060–1170 m, F/V *Belinda*, 12 February 1992, coll: K. Gowlett-Holmes (holotype, SAM H-908; schizoholotype, USNM 99410; paratype, SAM H-986). South Australia, Great Australian Bight, approx. 80 nautical miles (148 km) WSW of Pearson Id, in Investigator Group, 34°11'S, 132°38'E, 160 m, F/V *Comet*, 14 April 1979, coll: K. Gowlett-Holmes (paratype, SAM H-759). South Australia, Great Australian Bight, approx. 90 nautical miles (167 km) W of Cape Wiles, 38°04'S, 133°59'E, 625–890 m, F/V *Longa III*, 9 November 1989, coll: K. Gowlett-Holmes (paratype, SAM H-760).

Distribution

The species is currently known only from the waters off Tasmania and South Australia at depths of 160 to 1170 m.

Acknowledgments

Appreciation is extended to W. Zeidler, Karen Gowlett-Holmes, K. Olsson, and M. Cameron of the South Australian Museum for collecting the material and making it available for study and to Eric Matthews for editing the manuscript. Research space was kindly provided by S. Cairns of the USNM. Special thanks are extended to S. Braden of the USNM for taking the scanning electron micrographs. This work was supported in part by the Smithsonian Institution and by Oak Ridge National Laboratory, Oak Ridge TN.

Literature Cited

BROOK, G. 1889. Report on the Antipatharia. *Reports of the Scientific Results of the Voyage of the* Challenger, *Zoology*. **32**: 5–222.

DANA, J. D. 1846. 'Zoophytes'. United States Exploring Expedition during the years 1838–1842, under the command of Charles Wilkes, U.S.N., vol. 7. Lea and Blanchard: Philadelphia.

DUCHASSAING, P. 1870. 'Revue des zoophytes et des spongiaires des Antilles'. Paris.

EHRENBERG, C. G. 1834. 'Die Corallenthiere des rothen Meeres, physiologisch untersucht und systematisch verzeichnet'. Abhandlung Königlichen Akademie der Wissenschaften: Berlin.

ESPER, E. J. C. 1790. 'Die Pflanzenthiere in Abbildungen nach der Natur mit Farben erleuchtet nebst Beschreibungen', Vol. 2. Nürnberg.

GRAY, J. E. 1840. 'Synopsis of the contents of the British Museum', 42th ed. London.

MILNE EDWARDS, H. 1857. 'Histoire Naturelle des Coralliaires'. Vol. 1. Paris.

OPRESKO, D. M. 1999. Three new species of *Leiopathes* (Cnidaria: Anthozoa: Antipatharia) from southern Australia. *Records of the South Australian Museum* **31** (1): 99–111.

PALLAS, P. S. 1766. 'Elenchus Zoophytorum Sistens Generum Adumbrationes Generaliores et Specierum Cognitarum Succinctas Descriptiones cum Selectis Auctorum Synonymis'. Hagae-Comitum.

POURTALÈS, L. F. de. 1868. Contributions to the fauna of the Gulf Stream at great depths. *Bulletin of the Museum of Comparative Zoology* 1(7):103–120.

SILBERFELD, E. 1909. Japanische Antipatharien. *In* 'Beiträge zur Naturgeschichte Ostasiens', ed. F. Doflein. *Abhandlungen der math.-phys. Klasse der K. Bayer. Akademie der Wissenschaften* 7 (Suppl. 1): 1–30.

VAN PESCH, A. J. 1914. 'The Antipatharia of the *Siboga* Expedition'. Siboga-Expeditie Monographs, vol. XVII. J. Brill: Leiden.

SOUTHERN RIGHT WHALE REMAINS FROM 19TH CENTURY WHALING AT FOWLER BAY, SOUTH AUSTRALIA

CATHERINE M. KEMPER AND CATHERINE R. SAMSON

KEMPER, C. M. & SAMSON, C. R. Southern right whale remains from 19th century whaling at Fowler Bay, South Australia. *Records of the South Australian Museum* **32**(2): 155–172.

A study of surface and excavated whale bones at Fowler Bay, western South Australia, was carried out in 1994. Bones partially exposed at the surface were located over a 1 km transect and included up to 10 skulls and many postcranial bones. Eight sites were excavated and yielded 104 bones, many of which were well preserved and entire. Cranial and postcranial bones were excavated: six crania, a bulla, periotics, a mandible, ribs, vertebrae, chevrons and a sternum. All of the identifiable bones (two-thirds) were *Eubalaena australis*. Body lengths of five animals were derived from skull measurements and yielded estimates in the order of 15–18 m. Postcranial bones were also from full- or nearly full-grown right whales, as indicated by their size and developmental state. No bones of small animals were found. The minimum number of individual right whales in the deposit was six. It is likely that the remains were a result of whaling during the early part of the 19th century. The only available record of the number of whales taken at Fowler Bay is that of the log of the American ship 'Amazon' which took 33 right whales and 8 humpbacks in 1840. Indirect evidence suggests that at least 65 right whales were taken by shore- and/or ship-based bay whalers during 1840–1844. Although few right whales have visited Fowler Bay in the last decade, it must have been an important calving or nursery site before European settlement.

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Whaling in Australia underwent several phases. From about 1805 to 1845 bay whaling was at its height in suitable places along the southern coast (Dakin 1938) and the main target of the industry was the southern right whale, *Eubalaena australis*, during winter months when it came close to shore to calve and mate. Bay whaling included shore-based operations, both ephemeral and longer term, and ship-based operations from ocean-going American, British, French and Australian vessels which sheltered temporarily in safe inlets and often hunted whales from there (Dakin 1938).

Shore-based operations and Australian-registered ships took two-thirds of the estimated at least 26 000 right whales caught from 1827 to the early 1900s in New Zealand and southeastern Australian waters (Dawbin 1986). Three-quarters of these were caught between 1835 and 1844. British vessels were predominant until 1830, followed by a period of mostly American and French vessels after the mid 1830s. Eyre (1845) believed that at least 300 of the latter types were present each year in the general region. Records of the species and numbers taken are few, and rarely include details of size or maturity of the animals present in the catch. Historical estimates of right whale catches, therefore, are often based on oil yields by converting barrels, gallons or tuns to whales (Dawbin 1986).

Matthew Flinders was the first European to record having visited Fowler Bay, in January 1802, and he noted its good anchorage but lack of water and sparse vegetation (Faull 1988). Between November 1840 and January 1841 Edward John Eyre camped at Fowler Bay using it as a staging post for crossing the Nullarbor Plain. Good water was available in the sandhills. He later wrote:

> Upon walking round the shores of Fowler's Bay, I found them literally strewed in all directions with the bones and carcases of whales, which had been taken here by the American ship I saw at Port Lincoln, and had been washed on shore by the waves. To judge from the great number of these remains, of which very many were easily recognisable as being from those of distinct animals, the American must have had a most fortunate and successful season. (Eyre 1845: 227).

We have assumed that the skeletons observed by Eyre and/or taken in subsequent whaling

operations at Fowler Bay made up the remains which formed the basis of our study.

The presence of large bones partly exposed in sand along the northern side of Fowler Peninsula was brought to attention of the South Australian Museum in 1990. A preliminary trip was made in 1992 to locate these and photograph what was exposed. They were identified as whale bones, possibly *E. australis*. In August 1994 an expedition was mounted by the Australian and New Zealand Scientific Exploration Society (ANZSES), the South Australian Museum and Flinders University to excavate the bones and determine whether a whaling station had been set up at Fowler Bay. Archaeological expertise was provided by Mark Staniforth and Michael Jones,

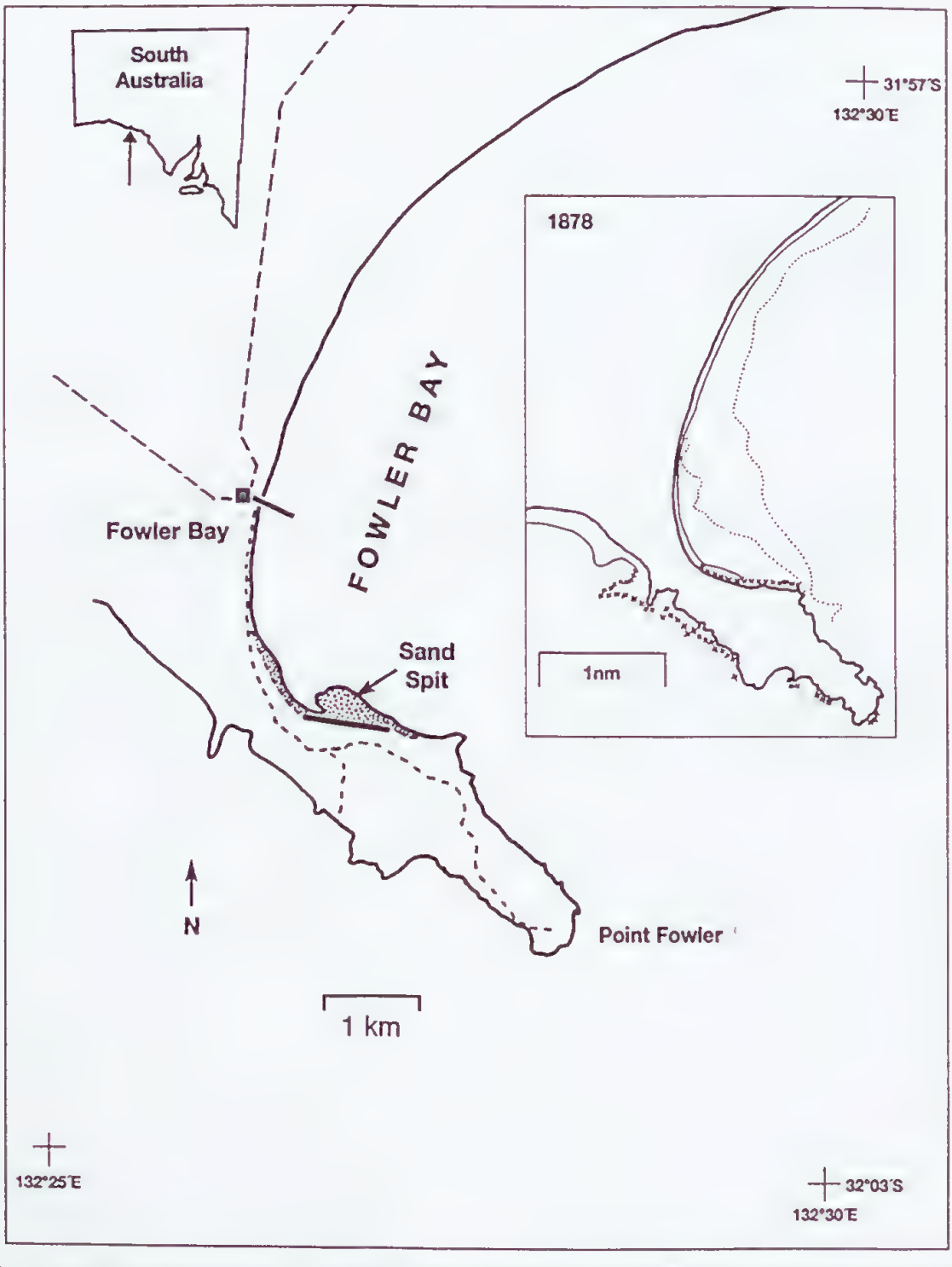

FIGURE 1. Fowler Bay area based on 1982 aerial photography and (insert) nautical chart based on 1878 survey by W. N. Goalen, Royal Navy. Solid bar near sand spit is position of study site. Broken lines are vehicle tracks and roads. Stippled lines on 1878 map indicate approximate positions of 2 and 6 m water depths. Low tide mark shown on 1878 map. Small crosses indicate rocky areas.

Flinders University, and is summarised in Jones and Staniforth (1996). Zoological expertise was provided by the authors and is reported here.

The aims of the zoological component of the project were to 1) identify the species represented by the bones, 2) determine the minimum number and relative age of whales present, 3) shed some light on whether shore- or ship-based whaling had taken place and 4) obtain reference specimens for the Museum's collection.

Study Site

Fowler Bay is near the head of the Great Australian Bight, about 300 km east of the South Australian/Western Australian border (Fig. 1). The bay is protected on its southwestern side by a calcarenite peninsula now covered by wind-blown, sandy hummocks and low vegetation. Mobile sand dunes are found where the peninsula meets the coast and these are gradually covering the old buildings of Fowler Bay township (Short, Fotheringham and Buckley 1986). Low coastal cliffs are present around the south and western side of the peninsula. A long sandy beach extends from about half way along the peninsula to Clare Bay, 25 km east. The beach and inshore area are gently sloping, resulting in a stable, low-energy and shallow bay along the coast to about 3 km north of the township of Fowler Bay (Short *et al.* 1986). The peninsula is part of Fowlers Bay Conservation Reserve.

An early nautical chart of the area, surveyed in 1878 (The Admiralty, 1939), showed no sign of the extensive sand spit now found on the northern side of the peninsula (Fig. 1). The first illustration which we could trace, showing the spit, was an aerial photo taken in 1963 (State Library of South Australia). Earlier maps, dated 1892, 1915 and 1951, are all very similar and appear to be based on the same survey. It is likely that the spit formed from eroded sands blown off the peninsula as a result of overgrazing by stock and rabbits during the early part of the 20th century. A vehicle track is now found along what is believed to be the old shore line.

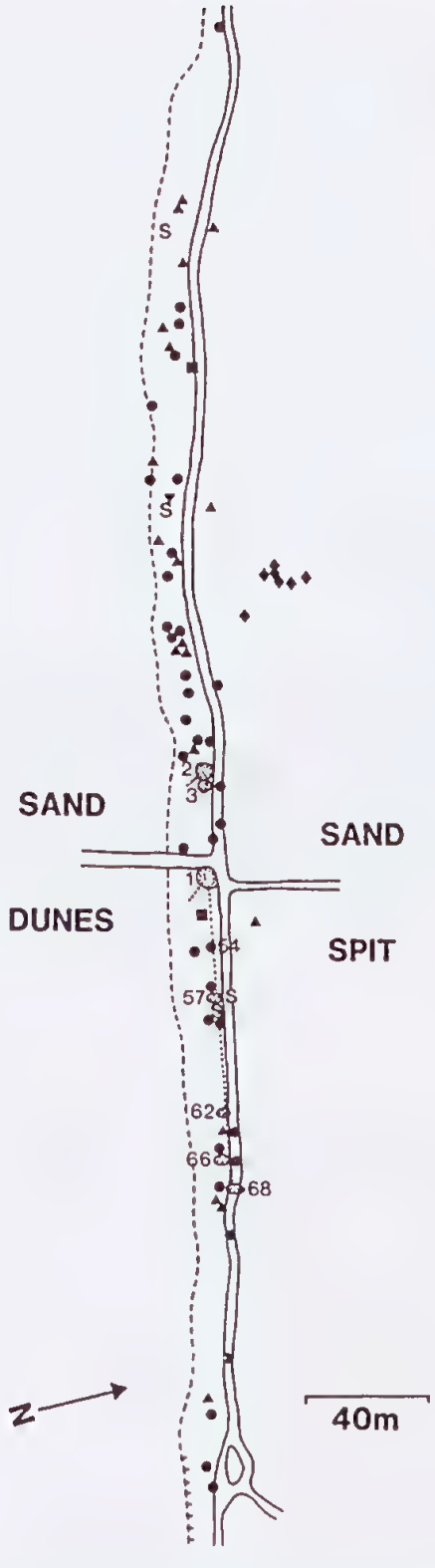

FIGURE 2. Location of surface bones, excavated sites and trenches in study site. Excavated sites shown as stippled areas with identifying W number (W1, W2, W3, W57, W62, W66, W68), except W54, which was found in a trench. Symbols of surface bones: ▲ vertebra, ■ rib, ▼ mandible, S possible right whale skull (not excavated), ● unknown large whale bone, ◆ beaked whale bones. Dotted lines are trenches. Position of track (between solid lines) and edge of sand dune/low limestone cliff (broken line and ⊥) shown.

Methods

Mapping and stratigraphy

A surface transect 1 km by 30 m was searched, using a line of 15 people spaced at 2 m intervals,

for exposed bones and cultural material along the length of the southwestern edge of the sand spit. The resulting sites (W1-77) were then surveyed by theodolite (Jones and Staniforth 1996).

A 40–50 cm-wide transect was established, digging 2 m out of each 5 m segment, between W1 and W68 sites (after the sites themselves had been excavated) to establish whether the bones were clumped or randomly spread between sites (Fig. 2). At 20 m intervals along this main trench, 2 m side trenches (total = four) were dug bearing south. Exploratory trenches were also dug from W1 (5.5 m bearing 126°) and W2 (3.3 m bearing 144°). All trenches were excavated to limestone platform level (<55 cm).

The stratigraphy of the sediments was recorded along the trench and at W1 site.

Excavations

When choosing sites for excavation, preference was given to those where exposed skulls rather than postcranial bones were already evident. Eight sites were excavated, of which two contained bones encountered during digging the trenches. At each site, excavation began at the exposed bone and worked down and around it, usually encountering other bones in doing so. Because so many bones were found piled on top of each other, the process was one of working towards the edge of the pile (which was not always reached due to time constraints) and leaving the bones in situ as the excavation progressed. Trowels, buckets, brushes and shovels were used. Each site was dug to the level of the limestone platform.

Photographs were taken of each site before, during and at the end of excavation. Sketches were also made of the site at completion and then each bone was numbered, measured and photographed (with a 1 m scale bar marked in 10 cm black and white bands) in situ. Measurements were taken (straight line, in cm) at the site using a tape measure. A few were later calculated from scaled photographs. The measurements are listed and defined in Appendix 1.

Twenty-six bones were collected for the South Australian Museum (Appendix 1). These were wrapped in toilet paper then jacketed in hessian and plaster before being transported to Adelaide. After preparation (including desalination), they were registered into the mammal collection (M18071). Some bones were also collected for National Parks and Wildlife South Australia and for display at Fowler Bay township.

After the two-week study was completed, the sites were filled-in with sand and the vegetation replaced. A sign explaining the results of the study has been erected at the site.

Identification

Preliminary identifications were made on-site by comparing excavated bones with published photographs and drawings of large whale skeletons. All identifications were then confirmed at the South Australian Museum. Reference material of large whale species there includes: the skull of an 11.5 m *E. australis* (M14135) plus the postcranial skeleton of two neonates (M16470, M17766), two skulls and part skeletons of juvenile humpback whales (*Megaptera novaeangliae*), skulls and skeletons of blue (*Balaenoptera musculus*) and Bryde's whales (*B. edeni*) and skulls and skeletons of a range of sizes of male and female sperm whales (*Physeter macrocephalus*). Published illustrations of northern right whale (*Eubalaena glacialis*) skulls and skeletons were also studied (True 1904, Allen 1908, Omura, Ohsumi, Nemoto, Nasu and Kasuya 1969, Omura, Nishiwaki and Kasuya 1971).

Estimating animal length

Maximum skull width was estimated from maximum available width by comparing photos of the incomplete, excavated skulls with drawings of skulls of *E. glacialis*. The proportion missing was then calculated and added to the maximum available width for each specimen. Maximum skull widths of 12 *E. glacialis* of known body length were obtained from published sources (True 1904, Allen 1908, Turner 1913, Omura *et al.* 1969, Omura *et al.* 1971) and measured in three *E. australis* (SAM M14135, WAM M40552, British Museum ZD.1934.7.23.1). Body lengths of these animals ranged from 7.6 to 17.1 m. Mean predicted body lengths and prediction limits were then computed following the methods in Kemper and Leppard (1999) using 17 m as the average adult length.

Results

Surface remains

The 1 km transect located 78 whale bones, or parts thereof, at 77 surface sites (Fig. 2). Of the 10 skulls located, all were initially identified as possible *E. australis* without excavating them (see example in Fig. 3). The remaining bones included whole or parts of 3 mandibles, 19 vertebrae, 2 ribs and 37 unknown bones. Of these, the recognisable

FIGURE 3. Weathered, posterior portion of *E. australis* skull at site W1 two years before excavation. Photo: A. McLennan, 1992.

ones were identified as possible *E. australis*. Seven strap-toothed beaked whale *Mesoplodon layardii* bones (M18070) were located at the surface in seagrass above high tide mark during the transect. They were probably the remains of a recent stranding.

Surface bones were not evenly distributed throughout the transect area. Few bones were found at the extremities of the area and only four (except the beaked whale bones) were located on the seaward (northern) side of the vehicle track. In some places groups of surface bones were observed.

Excavated sites

The stratigraphy of the deposit appeared to be similar. Fine grey/brown sand layers were mixed with layers of decomposed seagrasses. A layer of coarse beach sand, of variable thickness and sometimes including cobbles, was present just above the limestone platform. A black layer, including charcoal fragments, was present at a depth of about 20–25 cm at most places where the stratigraphy was recorded. At two places it was nearer the surface. This layer, and the fact that many of the bones were charred, suggests that a fire had occurred at the site when many of the bones were still exposed at the surface.

Six of the surface bone sites were excavated (W1, 2, 3, 57, 62, 68). Another two sites (W54, W66) were located while digging the trenches. A total of 104 entire or partial bones were located during excavations (Appendix 1). These included: 6 crania, 2 periotics, 1 bulla and periotic, and 7 skull fragments; 1 almost complete mandible and 5 possible (part) mandibles; 1 cervical mass, 29 thoracic and lumbar vertebrae, 6 caudal vertebrae, 7 part vertebrae and 5 loose epiphyses; 11 complete or almost-complete ribs and 12 rib fragments; 2 chevrons; 1 sternum; and 9 unknown fragments of bone.

At site W1, 29 bones, including a large cranium, were located in the 4.2 x 6.6 m excavated area. The site contained bones from several animals of various degrees of physical maturity e.g. large thoracic vertebrae with unfused or very well-fused epiphyses, posterior lumbar vertebrae with unfused epiphyses and mid

FIGURE 4. Overall view of site W2 looking south east. Bones in situ. Photo: J. Thurmer.

FIGURE 5. Postero-dorsal view of *E. australis* cranium W2-11 after it had been lifted upright and broken across occipital region. Scale bar is marked in 10 cm and 1 cm units. Photo: C. Kemper.

lumbars with well-fused epiphyses, a loose caudal epiphysis, and three periotics (Appendix 1). Several large ribs or part ribs were also found at this site. A continuous limestone platform was located 55 cm below the surface. No bones were found in the 5.5 metre-long side trench.

The area excavated at site W2 was 4.2 x 7.4 m and contained 45 whole or partial bones of various types and a large cranium (Figs 4, 5, Appendix 1). Bones from several individuals of differing stages of physical maturity were present: thoracic vertebrae with free or fused epiphyses and a caudal vertebra with unfused epiphysis; also bones encasing pterygoid fossae in addition to the skull. A continuous limestone platform lay 45 cm below the surface and limestone cobbles ranging in size from 5 to 25 cm long were common throughout the site. No bones were found in the 3.3 metre-long side trench.

W3 was a small site centred just 3 m east of the edge of W2 and eventually coalescing with it. The 14 bones were more broken up than at other sites and included a cranium of which only the basioccipital and right occipital condyle remained. The presence of both a thoracic vertebra with fused epiphyses and a caudal vertebra with unfused epiphyses indicated that at least two individuals, of different relative ages, were represented.

Site W57 contained a large cranium, large mandible and six other bones or fragments. Sites W62 and W68 each contained only a large cranium.

Three bones were located, each at different positions, in the trench between sites W1 and W68. In the main trench, 2 m from W68, a rib was located and at 7 m from W68, an almost complete, large cervical mass and a vertebra (W66) were found. One of the side trenches went very close to surface site W54 and a transverse process of a lumbar vertebra was found in the trench there. Further excavation of W54 revealed four other bones, including the rest of the same lumbar vertebra.

Species identification

Sixty-nine bones were sufficiently intact to identify them as *Eubalaena* sp. Since the southern right whale, *E. australis*, is the only species known to occur in Australian waters, we have

FIGURE 6. Postero-ventral view of *E. australis* cranium W57-1 in situ. The skull is partly resting on a large mandible (W57-2). Photo: C. Kemper.

FIGURE 7. Ventro-lateral view of right bulla and periotic (W1-28) of *E. australis*. Black and white scale bar is cm. Photo: Trevor Peters.

assumed that this is the species present in the material at Fowler Bay. Vertebral epiphyses, even when complete, were considered too difficult to assign to genus or species.

No skull was complete and what remained of five of the six excavated crania were the robust parts, including the occipital region and the squamosal bones (Figs 5, 6). The rostrum and frontals were missing and what remained of the skull looked worn. Distinctive features that the Fowler Bay skulls had in common with *Eubalaena* spp. were the large, squarish occipital shield (Fig. 5), the well-developed and ventroanteriorly projecting postglenoid process of the squamosal (Fig. 6), the deep pterygoid fossae (Fig. 6) and the large, distinctively-shaped bulla (Fig. 7). Identifiable fragments of skulls included the posterolateral tips of a frontal bone and maxilla. The part cranium at W3 was much less well preserved than the other excavated skulls and consisted of one half of a large occipital condyle, similar in shape to the condyles of the other skulls, and the adjacent portion of the squamosal. This skull was later identified as probable *E. australis* (Appendix 1).

The vertebrae were large, dense and robust, all of which are features typical of *Eubalaena* spp. The cervical vertebrae (Fig. 8) were fused into

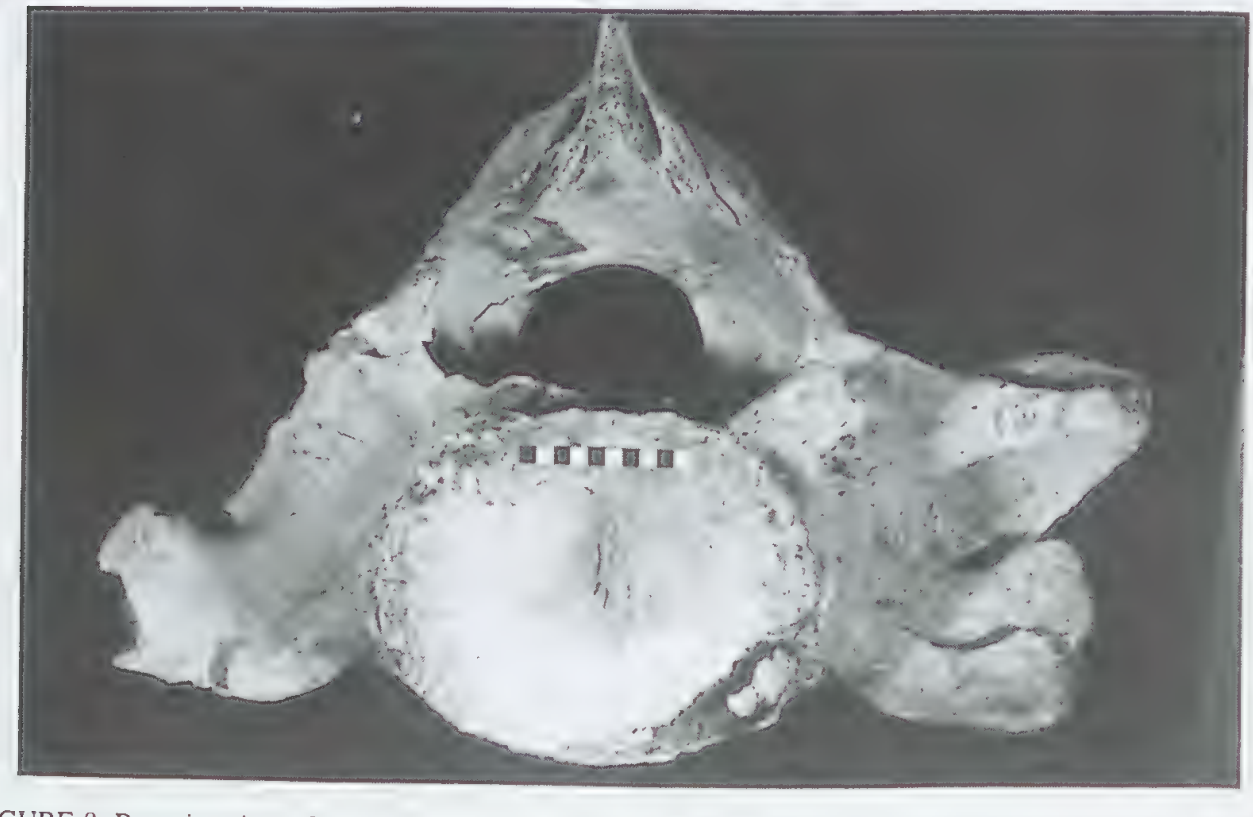

FIGURE 8: Posterior view of broken *E. australis* cervical vertebrae (W66-1). Thoracic vertebra, fused to seventh cervical, is in foreground. Scale bar is 10 cm long and marked in 1 cm units. Photo: Trevor Peters.

a

b

FIGURE 9. Right lateral (a) and posterior views (b) of mid-thoracic vertebra (W2-4) of *E. australis*. Black and white scale bar is cm. Photo: Trevor Peters.

one mass, a feature of Balaenidae and the very much smaller Neobalaenidae. In the Fowler Bay specimen the first thoracic vertebra was also fused to the cervical mass, suggesting it could have been from an old animal. The thoracic vertebrae had sub-triangular centra when viewed from front or back and the distal ends of their transverse processes were positioned well above the centra (Fig. 9). The prezygapophyses of the lumbar vertebrae projected quite far anteriorly and the transverse processes were narrow anteroposteriorly and thick dorsoventrally. The caudal vertebrae were almost round in cross-section and the neural spine of the mid-caudals had a rounded profile and remained the most obvious feature on the dorsal surface, relative to the prezygapophyses (Fig. 10).

The proximal end of the anterior ribs (ribs 1 and 2 were not found) had a tapered capitulum, a weakly developed tuberculum and an elongate collum. A deep depression was present on the anterior face of the proximal end of the anterior ribs (Fig. 11). The two excavated chevrons (Fig. 12) were comparable in size and shape with the ninth or tenth chevron of the 17 m *E. glacialis* studied by Omura *et al.* (1969). The almost-complete sternum was simple in outline (Fig. 13) and lacked the lateral 'wings' found in some balaenopterids. It was roughly similar in shape to the *E. glacialis* illustrated in Omura *et al.* (1969).

Size, relative age and number of individuals

The body lengths of the *E. australis* from Fowler Bay were estimated by comparing estimated maximum skull widths with those of known-length *Eubalaena* spp. using the same statistical procedures described in Kemper and Leppard (1999) for the pygmy right whale, *Caperea marginata* (Tables 1, 2). The resulting estimated body lengths of the five animals were in the order of 15 to 18 m.

The one almost-complete mandible, measured in situ, was at least 340 cm long. Compared with the mandible length of a 12.6 m female *E. glacialis* (318 cm) and 15.2 m male (446 cm) (Omura *et al.* 1969), the Fowler Bay specimen would have been at least 13 m body length.

The surface of the only bulla found was rugose (Fig. 7), suggesting that it was from an old animal. It was somewhat smaller (maximum length = 14.0 cm) than the bulla of the 11.5 m specimen at the South Australian Museum (M14135 maximum bulla length = 15.3 cm) but this could in part have

TABLE 1. Prediction statistics for estimating body length from measurements of maxmum skull width of 15 known-length *Eubalaena* spp.

Maximum Skull Width (cm)	Mean Predicted Body Length (m)	Lower Predicted Body Length (m)	Upper Predicted Body Length (m)
50	6.58	5.72	7.45
100	7.97	7.01	8.94
150	9.75	8.68	10.81
200	11.93	10.74	13.13
250	14.39	13.06	15.73
300	16.52	15.12	17.92

TABLE 2: Estimated skull widths and body lengths of *Eubalaena australis* from Fowler Bay, SA. Specimen numbers cross-referenced to Appendix 1.

Specimen No.	Available Width (cm)	Proportion Available	Estimated Skull Width (cm)	Estimated Body Length (m)
W1-8	205	73%	280	15–17
W2-11	202	58%	290	15–17
W57-1	240	75%	324	16–18
W62	200	60%	290	15–17
W68	214	67%	285	15–17

FIGURE 10. Anterior view of *E. australis* mid-caudal vertebra (W2-35). Dark areas are charred bone. Black and white scale bar is cm. Photo: Trevor Peters.

been because the Fowler Bay specimen was quite weathered. The *E. australis* bullae listed by Dixon (1990) had maximum lengths of 14.1 to 16.9 cm. Bulla size has limited use as a predictor of body length of baleen whales (Kemper and Leppard 1999).

All of the excavated postcranial bones were large and well formed, and were therefore not from calves or young subadults. Of the 36 vertebrae, 24 had fused epiphyses and were therefore from animals having reached or approaching physical maturity. Of the 24 vertebrae with fused epiphyses, 11 were thoracic and therefore from physically mature animals. The vertebrae with unfused epiphyses were all large and appeared to be from

TABLE 3: Centrum widths (cm) of two known-length *Eubalaena glacialis* (Omura *et al.* 1971) compared with those of Fowler Bay vertebrae. Centrum widths of known-length animals are means of the full series for each skeleton. n = number of vertebrae.

Vertebral region	15.2 m male	12.6 m female	Fowler Bay
Anterior thoracic	29	26	24–32 (n = 6)
Posterior thoracic	32	29	28 (n = 2)
Lumbar	35	30	25–30 (n = 3)

FIGURE 11. Proximal ends of anterior ribs (W1-6, W1-7) in situ. Scale bar is marked in 10 cm and 1 cm units. Photo: C. Kemper.

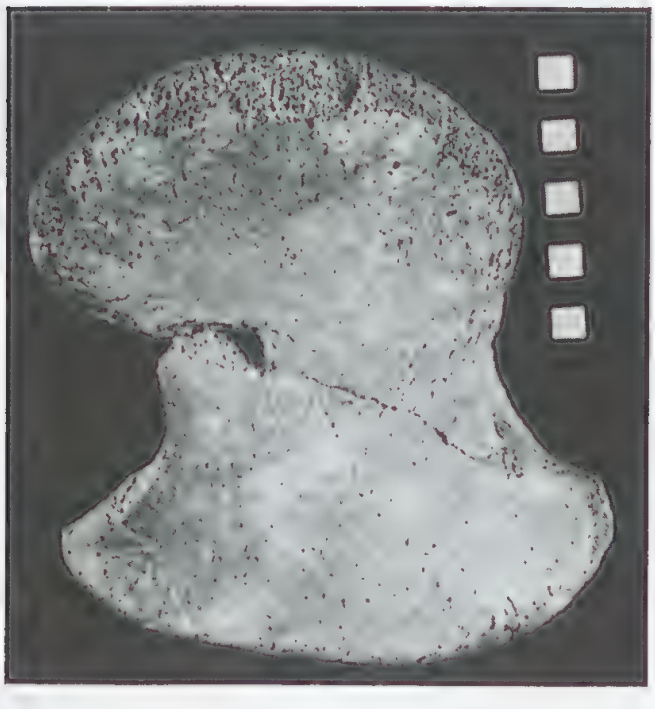

FIGURE 12. Left lateral view of *E. australis* chevron (W1-30). Black and white scale bar is cm. Photo: Trevor Peters.

animals that were at least 12 m body length (Table 3). The 11 complete or almost-complete ribs measured 104–210 cm in length. Anterior ribs measured 174 to >203 cm and were roughly comparable to the lengths of the anterior ribs (193–237 cm, excluding the first rib) of the 17 m *E. glacialis* studied by Omura *et al.* (1969).

The number of individual whales found in the remains was determined by counting the skulls: five excavated and positively identified as *E. australis*, one excavated and probably *E. australis* and four not excavated and possibly *E. australis*. The minimum number is therefore six, possibly 10, individual right whales.

Discussion

An estimate of the number of right whales taken by local bay whaling operations in Western Australian coastal waters in the period 1836–1878 was made by Bannister (1986), while Dawbin (1986) compiled a total for southeastern Australian coastal waters and New Zealand, taken

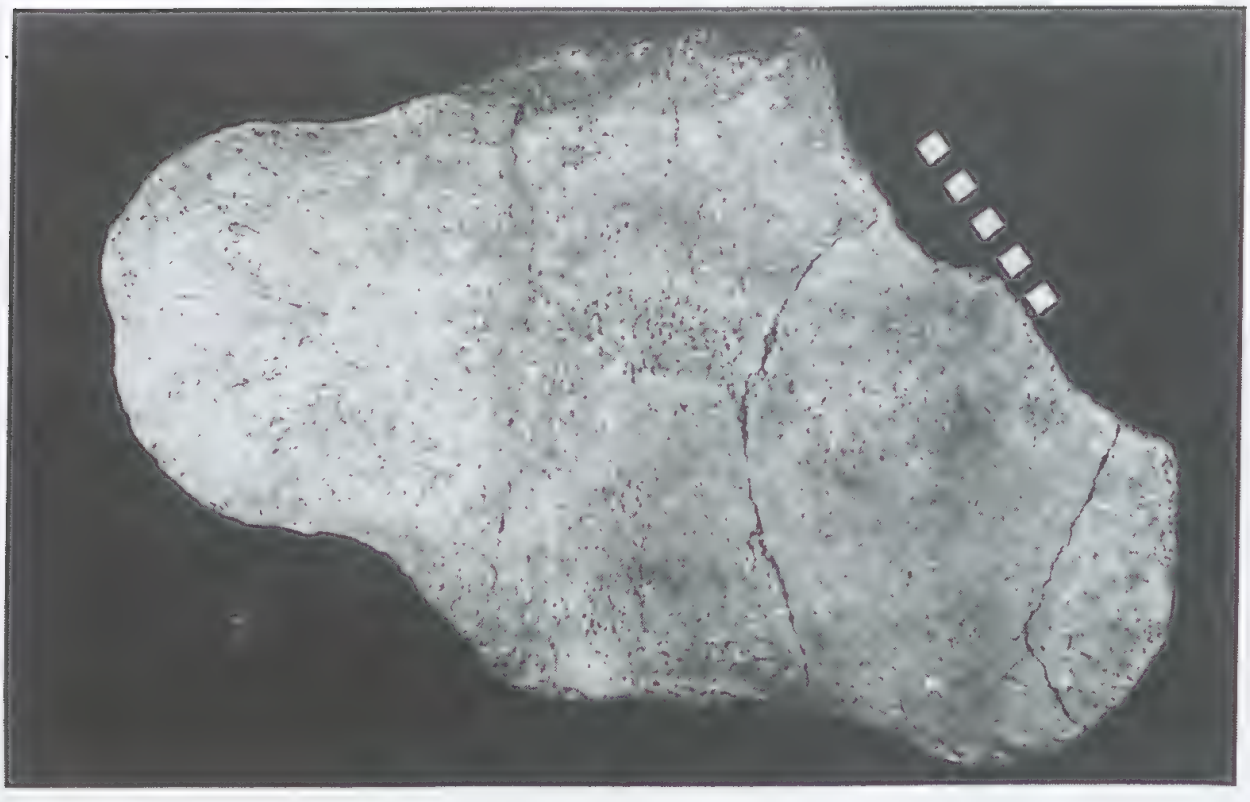

FIGURE 13. Ventral view of probable *E. australis* sternum (W3-11). Black and white scale bar is cm. Photo: Trevor Peters.

by both local and pelagic whalers. At least 13 000 right whales were taken from coastal waters of Victoria, New South Wales, Tasmania and South Australia, three quarters during the decade 1835–1844 (Dawbin 1986). The total for South Australia was 379 and all were from east of Port Lincoln. Bannister (1986) totalled at least 266 for southwestern Australia during 1836–1866. In addition, he noted a number of pelagic bay whaling catches, including that of the 'Amazon', which caught 33 right whales (including 13 calves) and 8 humpbacks (including 3 calves) in 80 days between 10 June and 28 August 1840. The other ship logs listed by Bannister (1986) are all too far south or west to have been in the Fowler Bay area. Sexton (1990) noted that another American whaling ship, 'Martha', was in Fowler Bay during the winter of 1840 but no records are available of the number of whales caught or the barrels of oil it carried when it visited Port Lincoln on 22 September.

Other vessels must certainly have caught whales in the area, some probably at Fowler Bay itself. Parsons (1981) reported that during 1840 four French and one American whaler 'fished' between Port Lincoln and Fowler Bay, and in 1841 six foreign whalers were in the same region. In 1843 and 1844, Copping (State Library of Tasmania reference CRO.Q.639.22, in Jones and Staniforth 1996) recalls taking about 70 and 90 'tons' of oil, respectively, at 'Fowlers Bay' on the Tasmanian ship, 'Grecian'. In the early 19th century whale oil was usually measured in tuns or barrels (volume measurements) but it could also have been measured in tons (weight measurement). We have assumed that Copping's reminiscences really meant 'tuns'. The conversion for tuns of oil to whale individuals used by Bannister (1986) and Dawbin (1986) was 5 tuns per whale. Assuming that it was right whales that were being taken and that most were adults, the catches made by the 'Grecian' during 1843 and 1844 were therefore about 14 and 18 whales, respectively. This brings the minimum total catches for right whales at Fowler Bay to at least 65 animals during 1840–1844. It is likely that the true number taken there was much higher.

The period of whaling at Fowler Bay was probably very short-lived, with its height during 1840–1844, as it was elsewhere (Dawbin 1986, Bannister 1986). Recent surveys of southern right whales in the Great Australian Bight have shown that animals are now rare at Fowler Bay. On annual survey flights in the period 1993–98, the only animals recorded in Fowler Bay have been two cow-calf pairs in 1993 and five adults in 1997 (J. Bannister, pers. comm. 1998). This is in contrast to the Head of Bight, 150 km to the west,

where 179 individual adult (i.e. non-calf) whales have been recorded during shore-based studies from 1991 to 1994 (Burnell and Bryden 1997). Since Fowler Bay was a good anchorage for whaling ships, many more whales may have been taken there than at Head of Bight, where it would have been unsafe to anchor during foul weather. Southern right whales have an approximately 3 year calving cycle and adult females return to the coast at least once during that time to give birth (Bannister 1990, Best 1990). If fidelity to calving site is a feature of the life history of this species, it could have taken less than 10 years to decimate this important pre-European calving or nursery site.

The log of the 'Amazon' recorded 13 calves yet no bones of calves were found in our sample of 69 identifiable bones. The skeleton of a calf whale is not fully developed, is fragile and the bones of the skull are not fully fused. Wave action and exposure to ultraviolet rays could have easily weathered the bones to such a degree that they would not remain intact over the intervening 150 years. If the bones of calves are still present they may be in the deeper silts of the spit that has built up on the northeastern side of the peninsula since last century or on the sea floor. However, a cursory search by snorkelling in sediment-filled water at the edge of the spit found no bones during our study in 1994. Cumbaa (1986) found many submerged and well-preserved bones of *E. glacialis* and bowhead whales *Balaena mysticetus* at a Basque whaling site in Labrador 400 years after the animals had been taken. Only one animal in the <1 year age group (and one possible foetus) was found in Cumbaa's sample of 17 individuals but this low proportion is to be expected since Labrador was unlikely to have been a calving ground for *B. mysticetus* (Burns, Montague and Cowles 1993).

Estimating body length from maximum skull width has been used by researchers of bowhead whale hunt remains in the Canadian Arctic (Savelle and McCartney 1994) and to predict body length of stranded *C. marginata* (Kemper and Leppard 1999). In our study of *E. australis* remains at Fowler Bay the predicted body lengths were considered rough approximations because two sources of error were likely. The skull measurements of known-length animals were obtained from a variety of publications which did not illustrate the points of measurement and we had to estimate skull width itself due to the incompleteness of the skulls.

Maximum body length of *E. australis* is 17.5 m (Bannister, Kemper and Warneke 1996) and recent estimates of live adults off South Africa are 12.4–15.5 m (Best and Ruther 1992). Physical maturity, when all vertebrae have fused epiphyses and body length is maximum, occurs at about 16 m and sexual maturity at 12–13 m (Bannister *et al.* 1996). Body lengths of five Fowler Bay animals were estimated (from skull measurements) at 15–18 m and most of the postcranial bones were from large and/or physically mature animals. Their size suggests that they were also sexually mature. The fact that the bones of no obvious yearlings or subadults (i.e. about 8–12 m) were located suggests that these were not common in the deposit, although a much larger sample of bones would be required to confirm this. The log of the 'Amazon' reported that 13 of the 33 right whales taken were calves (Bannister 1986). Assuming that at least an equal number of adult females were taken (i.e. the mothers of the calves), this leaves seven animals that could have been adults or subadults.

There are no confirmed records of the existence of a shore-based whaling station at Fowler Bay (Kostoglou and McCarthy 1991). During the present study no concrete archaeological evidence of a shore-based operation was found, although the presence of an extensive rock platform under the bones suggested that it would have been a suitable site for one (Jones and Staniforth 1996). However, a shore-based operation would not have had any advantage over flensing the animals by the side of the whale ship and boiling the blubber on deck as they would if the ship were out to sea. There may even have been disadvantages on shore in that the southwestern part of the bay was very shallow (Fig. 1).

When Eyre (1845:227) visited Fowler Bay in 1840 he noted that whale bones and carcasses 'were strewed in all directions' on the beach. Without a thorough search of the whole shore and bay, including under water, we do not know whether our study site was extraordinarily dense in bones compared with the rest of the bay. It may have been that the bones simply persisted there for longer because they were protected from the prevailing southwesterlies, and because they were covered by sand and silt blown from the peninsula to the south and deposited in this low energy section of the bay (Short *et al.* 1986). The excavated skulls and many of the other bones were broken, worn and disarticulated, and there were large cobbles amongst them. This suggests that the skeletons experienced strong wave action at some time after the carcasses disintegrated,

probably during easterly or southeasterly storms. Coarse material, suggesting that it had been deposited during storms, was found in the lower stratigraphic layers at the excavated sites (Jones and Staniforth 1996). If the study site was the densest accumulation of bones, there are two explanations for it being in the southwesterly part of the bay. 1) Whalers processed animals on the extensive rock platform there (not found elsewhere in the bay) and/or 2) the ships often anchored just to the east of our study area. Here the water depth would have been >4 fathoms (about 7 m), possibly deep enough for a whaling barque of up to 300 tons and drawing about 15–20 feet of water (4.5–5.5 m, Church 1938), and it would have been relatively close to shore. This position would have provided the most protection during the prevailing winter south and southwesterly winds (Bannister, pers. comm.). Wave refraction around Point Fowler (Short *et al.* 1986) could have deposited carcasses and/or bones, and subsequently silt and sand, where our study site was.

If future studies of the whale bones at Fowler Bay are carried out they should include submarine searches for bone and archaeological material. This may provide better information on the number of animals taken and the proportions of different whale age classes, as well as evidence of either shore- or ship-based whaling.

Acknowledgments

We thank Kingsley Turner for advising CK that whale bones were present at Fowler Bay. This study would not have been possible without the logistic organisation of the expedition by ANZSES, the science leaders Debbie Thiele and Claire Green, and the enthusiastic assistance of the expeditioners. In particular, we would like to thank Nola Haines, June Barker, Dave and Betty King, Fay Norton, Sally Symonds, Anne Watkins, Michael Giacometti, Jennifer Thurmer and Brett Bannerman. Marg and Mo Wheadon, of the Fowler Bay shop, were most helpful in providing supplies and much-needed showers.

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National Parks and Wildlife South Australia gave permission to conduct the study in the reserve and put up the information sign which now stands at the site.

Phillip Leppard ran the statistics for estimating whale body length. Richard Sabin kindly measured a *E. australis* skull in the Natural History Museum (London). Trevor Peters took the photos of the collected bones and Jennifer Thurmer provided advice on the line drawings.

References

ALLEN, J. A. 1908. The north Atlantic right whale and its near allies. *Bulletin of the American Museum of Natural History* **24**: 277–329.

BANNISTER, J. L. 1986. Notes on nineteenth century catches of southern right whales (*Eubalaena australis*) off the southern coasts of Western Australia. *Reports of the International Whaling Commission (Special Issue No.* **10***)*: 255–259.

BANNISTER, J. L. 1990. Southern right whales off Western Australia. *Reports of the International Whaling Commission (Special Issue* **12***)*: 279–288.

BANNISTER, J. L., KEMPER, C. M. & WARNEKE, R. M. 1996. 'The Action Plan for Australian Cetaceans'. Australian Nature Conservation Agency: Canberra.

BEST, P. B. 1990. Natural markings and their use in determining calving intervals in right whales off South Africa. *South African Journal of Zoology* **25**: 114–123.

BEST, P. B. & RUTHER, H. 1992. Aerial photogrammetry of southern right whales, *Eubalaena australis*. *Journal of Zoology, London* **228**: 595–614.

BURNELL, S. R. & BRYDEN, M. M. 1997. Coastal residence periods and reproductive timing in southern right whales, *Eubalaena australis*. *Journal of Zoology, London* **241**: 613–621.

BURNS, J. J., MONTAGUE, J. J. & COWLES, C. J. (eds). 1993. 'The Bowhead Whale'. Special Publication No. 2, The Society for Marine Mammalogy: Lawrence, Kansas.

CHURCH, A. C. 1938. 'Whale Ships and Whaling'. W. W. Norton: New York.

CUMBAA, S. L. 1986. Archaeological evidence of the 16th century Basque right whale fishery in Labrador. *Reports of the International Whaling Commission (Special Issue No.* **10***)*: 187–190.

DAKIN, W. J. 1938. 'Whalemen Adventurers' revised edition. Angus and Robertson: Sydney. Reprinted by Sirius Books in 1963.

DAWBIN, W. H. 1986. Right whales caught in waters around south eastern Australia and New Zealand during the nineteenth and early twentieth centuries. *Reports of the International Whaling Commission (Special Issue No.* **10***)*: 261–267.

DIXON, J. M. 1990. Record of a southern right whale (*Eubalaena australis*) skeleton from Altona Bay, Victoria, Australia. *Victorian Naturalist* **107**: 159–162.

EYRE, E. J. 1845. 'Journals of Expeditions of Discovery into Central Australia, and Overland from Adelaide to King George's Sound, in the Years 1840–1'. T. & W. Boone: London. (Australiana Facsimile Editions No.7, 1964).

FAULL, J. 1988. 'Life on the Edge. The Far West Coast of South Australia'. South Australian Centre for Settlement Studies Publication: Adelaide.

JONES, M. D. & STANIFORTH, M. 1996. Fowlers Bay Whaling Site Archaeological Program. Unpublished report to The Australian and New Zealand Scientific Exploration Society.

KEMPER, C. M. & LEPPARD, P. (1999). Estimating body length of pygmy right whales (*Caperea marginata*) from measurements of the skeleton and baleen. *Marine Mammal Science* **15**: 683–700.

KOSTOGLOU, P. & McCARTHY, J. 1991. Whaling and sealing sites in South Australia. *Australian Institute for Maritime Archaeology Special Publication No. 6*. State Heritage Branch, Department of Environment and Planning: Adelaide.

OMURA, H., NISHIWAKI, M. & KASUYA, T. 1971. Further studies on two skeletons of the black right whale in the north Pacific. *Scientific Reports of the Whales Research Institute* **23**: 71–81.

OMURA, H., OHSUMI, S., NEMOTO, T., NASU, K. & KASUYA T. 1969. Black right whales in the north Pacific. *Scientific Reports of the Whales Research Institute* **21**: 41–65.

PARSONS, R. H. 1981. 'Port Lincoln Shipping'. R. H. Parsons: Adelaide.

SAVELLE, J. M. & McCARTNEY, A. P. 1994. Thule Inuit bowhead whaling: a biometrical analysis. Pp. 281–310 *in* 'Threads of Arctic Prehistory: Papers in Honour of William E. Taylor, Jr.'. Eds D. Morrison and J.-L. Pilon. Archaeological Survey of Canada Mercury Series Paper 149, Canadian Museum of Civilization.

SEXTON, R. T. 1990. 'Shipping Arrivals and Departures South Australia 1627–1850'. Gould Books: Roebuck Society.

SHORT, A. D., FOTHERINGHAM, D. G. & BUCKLEY, R. C. 1986. Coastal morphodynamics and Holocene evolution of the Eyre Peninsula coast, South Australia. Coastal Studies Unit Technical Report 86/2, Department of Geography, University of Sydney.

THE ADMIRALTY, 1939. Survey of Port Eyre by W. N. Goalen, under the direction of Commander F. Howard, Royal Navy, in 1878. London.

TRUE, F. W. 1904. The whalebone whales of the western north Atlantic. *Smithsonian Contributions to Knowledge* **33**: 244–268.

TURNER, W. 1913. The right whale of the north Atlantic, *Balaena biscayensis*: its skeleton described and compared with that of the Greenland right whale, *Balaena mysticetus*. *Transactions of the Royal Society of Edinburgh* **48**: 889–922.

APPENDIX 1. Details of excavated bones at the Fowler Bay site. Reliability of identification: 1 = *E. australis* with certainty, 2 = *E. australis* probable, 3 = unknown large whale species. Measurements: L = length, W = width, H = height, CW = maximum centrum width, CH = maximum centrum height, TPW = distance between the extremities of the transverse processes, TH = height of the vertebra from the ventral side of the centrum to the dorsal extremity of the neural spine, WBPF = width between pterygoid fossae, GW = maximum available width of skull, SOW = supraoccipital width, bulla L = maximum length of bulla, rib length = maximum length in a straight line from end to end, chevron length = length of dorsal articulating surface. ( ) = measured from photographs. * = collected for SA Museum.

Bone Type	Species	Measurements (cm)	Specimen Number
Site W1			
cranium	1	GW>205, SOW = 70	W1-8
left periotic*	1		W1-26
left periotic*	1		W1-27
right bulla and periotic*	1	bulla L = 13:4, max. L = 14.0	W1-28
unknown part of skull	3	L =45, W = 15	W1-5
possible part mandible	3		W1-15
single-headed, posterior rib	2	L = 185, W = 10	W1-1
single-headed, posterior rib	2	L = 210, W = 16	W1-2
double-headed, anterior rib	3	L = 185, W = 10	W1-3
part anterior rib	2		W1-4
double-headed, anterior rib	2	L = 174, W = 12	W1-6
double-headed, anterior rib	2	L = 207, W = 13	W1-7
possible posterior rib	3	L >104, W = 5	W1-10
part rib	3		W1-9
mid-thoracic vertebra, epiphyses fused*	1	CW = 35, TPW = 33x2	W1-11
anterior thoracic vertebra, no epiphyses*	1	CW = 24, CH = 19, TPW = 47, TH = 49	W1-14
anterior thoracic vertebra, epiphyses fused*	1	CW = 26, CH = 23, TH = 63	W1-18
anterior thoracic vertebra, epiphyses free	1	CW = 25, CH = 21, TPW = 49	W1-22
posterior lumbar vertebra, epiphyses free*	1	CW = 25, CH = 22, TPW = 69	W1-16
mid-lumbar vertebra, epiphyses fused	1	CW = 29, CH = 25, TPW = ~88	W1-19
mid-lumbar vertebra, epiphyses fused*	1	CW = 33, CH >23	W1-20
anterior caudal vertebra, epiphyses fused	1	CW = 34, CH = 32, TPW >66	W1-17
anterior caudal vertebra, epiphyses fused ?	1	CW = 30, CH = 31	W1-29
caudal vertebral epiphysis	3	–	W1-13
transverse process of vertebra	2	L = 35	W1-21
chevron*	1	H = 19.4, ventral L = 15.6	W1-30
possible rib or premaxilla	3		W1-23
unknown mass of bone	3		W1-12
bone fragments	3		W1-24
Site W2			
cranium	1	GW >202, WBPF = 56	W2-11
pterygoid fossae of skull*	1		W2-6
posterior tip of maxilla*	1	W = 15	W2-42
distal tip of frontal*	1	~50	W2-43
possible part of skull	3		W2-38
possible part mandible	3	W >22, L>110	W2-13
possible part mandible	3	W ~ 28	W2-15
possible part mandible	3	L >146, W >33	W2-27
double-headed, anterior rib	1	L = 193, W = 12	W2-8
double-headed anterior rib	1	L = 190, W = 14	W2-10
posterior rib	2	L = 173, W = 12	W2-12
double-headed, anterior rib*	1	L >200	W2-23
possible anterior rib	2	L >203	W2-26

Bone Type	Species	Measurements (cm)	Specimen Number
part rib	3		W2-32
possible part rib	3		W2-5
part rib	3	L >78	W2-25
anterior thoracic vertebra, epiphyses free*	1	CW = 32, CH = 23, TPW = 60, TH = 64	W2-4
anterior thoracic vertebra, epiphyses fused*	1	CW = 29, CH = 21, TPW = 45	W2-14
anterior thoracic vertebra, epiphyses free?	1	CW = 29, CH = 23	W2-22
anterior thoracic vertebra, epiphyses fused*	1	CW = 28, CH = 19, TPW = 52	W2-29
mid-thoracic vertebra, epiphyses fused	1	CW = 27, CH = 23, TPW = 40x2	W2-30
thoracic vertebra, epiphysis free	1	CW = 28, CH ~26	W2-33
mid-thoracic vertebra, epiphyses fused	1	CW = 28, CH = 22	W2-34
anterior thoracic vertebra, epiphyses fused	1	CW = 27	W2-36
anterior thoracic vertebra, epiphyses fused	1	CW = 26, CH = 21, TPW = 28x2	W2-37
anterior thoracic vertebra, epiphyses free	1	CW = 27, CH = 23	W2-44
posterior lumbar vertebra, epiphyses fused	1	CW = 34, CH = 32	W2-2
mid-lumbar vertebra, epiphyses fused	1	CW = 34, CH = 21, TPW = 45	W2-16
mid-lumbar vertebra, epiphyses free	1	CW = 30, CH = 27, TPW >86	W2-20
mid-lumbar vertebra, epiphyses fused	1	CW = 32, CH = 31, TPW = 44x2	W2-28
lumbar vertebra, epiphyses free	1	CW = 28, CH ~25	W2-39
possible lumbar vertebra, epiphyses fused?	2	CW ~30, CH ~32	W2-17
posterior caudal vertebra, epiphyses fused*	1	CW = 31, CH = 32	W2-19
mid-caudal vertebra, epiphyses free?*	2	CW = 33, CH = 33	W2-35
posterior caudal vertebra, epiphyses free*	1	CW = 28, CH = 30	W2-40
caudal vertebral epiphysis*	3	diameter = 31	W2-1
thoracic or lumbar vertebral epiphysis*	3	W = 29	W2-9
vertebral epiphysis*	3	W = 24, H = 18	W2-21
transverse process of vertebra ?	3		W2-31
neural spine of vertebra*	2		W2-18
transverse process of vertebra	2		W2-7
possible neural spine of vertebra	3		W2-3
chevron*	1	H = 19, L = 4	W2-45
unknown	3		W2-41
unknown	3		W2-24
Site W3			
part cranium (occipital condyle, part squamosal)	2		W3-3
part of frontal bone of skull	1	W = 24	W3-2
part rib	3	W =12	W3-10
rib fragment	3	W = 8	W3-13
rib? fragment	3		W3-14
distal part of rib	3	W = 11	W3-5
anterior thoracic vertebra, epiphyses free	1	CW = 24, CH = 20, TPW = 23x2	W3-1
thoracic vertebra, epiphysis fused	2	CH = 23	W3-7
part thoracic vertebra	3		W3-12
transverse process of thoracic or lumbar vertebra	2	L = 28	W3-4
caudal vertebral epiphysis	3	diameter = 29	W3-9
sternum*	2	L = 45, W = 29	W3-11
unknown	3		W3-6
unknown	3		W3-8
Site W54			
possible part mandible	3		W54-4
proximal fragment of rib	2		W54-3
lumbar vertebra, epiphyses fused	1	CW = 31, CH = 29, TPW = 44x2, TH = 75	W54-1
posterior caudal vertebra, epiphyses fused	2	diameter = 31	W54-2

Bone Type	Species	Measurements (cm)	Specimen Number
Site W57			
cranium	1	(GW >240)	W57-1
left mandible	1	L >340	W57-2
double-headed, anterior rib	1	L >153	W57-3
mid-thoracic vertebra, epiphyses fused	1	CW = 24, CH = 22, TPW = 28x2	W57-5
lumbar vertebra, epiphyses fused	1	CW = 42, CH = 26, TH = 80	W57-4
unknown	3		W57-6
unknown	3		W57-7
unknown	3		W57-8
Site W62			
cranium	1	(GW >200)	W62
Site W66			
cervical vertebrae*	1	max. H ~ 45, max. W ~ 74	W66-1
posterior thoracic vertebra, epiphyses fused	1	(CW = 28, CH = 26)	W66-2
Site W68			
cranium	1	(GW >214)	W68

GENETIC VARIATION AND TAXONOMY OF THE LIZARDS ASSIGNED TO *CTENOTUS UBER ORIENTALIS* STORR (SQUAMATA: SCINCIDAE) WITH DESCRIPTION OF A NEW SPECIES

MARK N. HUTCHINSON & STEPHEN C. DONNELLAN

MARK N. HUTCHINSON & STEPHEN C. DONNELLAN 1999. Genetic variation and taxonomy of the lizards assigned to *Ctenotus uber orientalis* Storr (Squamata: Scincidae) with description of a new species. *Records of the South Australian Museum* 32(2): 173–189.

Analysis of allozyme and morphological variation reveals that at least two scincid lizard species are presently confused under the trinomial *Ctenotus uber orientalis*. The status of *orientalis* is reassessed here with its elevation to a full species, while a new species is described from central South Australia, extending narrowly into adjacent areas of the Northern Territory, New South Wales and Queensland. This study reveals that significant genetic divergence has occurred within and between species groups of the large genus *Ctenotus*.

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Storr (1969) described *Ctenotus uber* from Western Australia as part of his initial taxonomic review of *Ctenotus*, Australia's largest genus of terrestrial vertebrates. In 1971 he described an eastern subspecies, *C. u. orientalis*, the only form recognised east of Western Australia. A third taxon, *C. u. johnstonei* was later described from northern Western Australia (Storr 1980). These taxa are all members of the *Ctenotus leonhardii* species group, one of several defined by Storr (1970, Storr *et al.* 1981, King *et al.* 1988) to aid identification. The phylogenetic relationships within and between Storr's species groups are yet to be studied.

There is considerable morphological variation in populations assigned to both of the widespread subspecies, *C. u. uber* and *C. u. orientalis*. The latter subspecies includes blackish, heavily spotted lizards, mostly distributed in the semi-arid to dry temperate woodlands of southern South Australia, Victoria and southern New South Wales, as well as populations of much plainer animals which inhabit arid chenopod and gibber habitats in the Lake Eyre basin through eastern South Australia to western New South Wales. Such apparent ecological and morphological plasticity is unusual in a single species and prompted us to question whether one or more cryptic species might be included within *C. u. orientalis* (Donnellan *et al.* 1993). It also led us to revisit the taxonomy of *orientalis* with respect to *uber*.

Materials And Methods

We followed Storr (1969 *et seq.*), Greer (1982), King *et al.* (1988) and Hutchinson and Rawlinson (1995) in defining and describing morphological characters, such as scalation and proportions. Specimens examined were from the collections of the South Australian Museum, Adelaide (SAMA) and Western Australian Museum, Perth (WAM), and eastern Australian specimens in the Australian Museum, Sydney (AMS) and the Museum of Victoria, Melbourne (NMV).

Thirty-one specimens of South Australian *C. u. orientalis* were analysed for electrophoretic variation. These encompassed all of the morphological variation known and represented a wide geographical sampling. In order to assess the significance of any variation found, we also typed samples of three other morphologically similar South Australian species of *Ctenotus*—*C. leonhardii, C. regius* and *C. septenarius* (members of the *C. leonhardii* species group, Storr 1970). The morphologically distinct *Ctenotus strauchii varius* (*C. colletti* species group) was included as a more distant outgroup.

Our methods for allozyme electrophoresis using cellulose acetate gels ('Cellogel', Chemtron, Milan) follow Richardson *et al.* (1986). We scored the protein and enzyme products of 42 presumed loci for patterns of allelic variation. The proteins that were stained, abbreviations used and their Enzyme Commission numbers (International

Union of Biochemistry 1984) were: aspartate aminotransferase (AAT, EC 2.6.1.1), aconitate hydratase (ACOH, EC 4.2.1.3), acid phosphatase (ACP, EC 3.1.3.2), aminoacyclase (ACYC, EC 3.5.1.14), alcohol dehydrogenase (ADH, EC 1.1.1.1), albumen (ALB), carbonate dehydratase (CA, EC 4.2.1.1), diaphorase (DIA, EC 1.6.99.?), enolase (ENO, EC 4.2.1.11), esterase (EST, EC 3.1.1.?), fructose-bisphosphatase (FBP, EC 3.1.3.11), fumarate hydratase (FUMH, EC 4.2.1.2), glyceraldehyde-3-phosphate dehydrogenase (GAPDH, EC 1.2.1.12), glycerol-3-phosphate dehydrogenase (G3PDH, EC 1.1.1.8), glucose-6-phosphate dehydrogenase (G6PDH, EC 1.1.1.49), glucose-6-phosphate isomerase (GPI, EC 5.3.1.9), glutamate dehydrogenase (GTDH, EC 1.4.1.3), 3-hydroxybutyrate dehydrogenase (HBDH, EC 1.1.1.30), L-iditol dehydrogenase (IDDH, EC 1.1.1.14), isocitrate dehydrogenase (IDH, EC 1.1.1.42), cytosol aminopeptidase (LAP, EC 3.4.11.1), L-lactate dehydrogenase (LDH, EC 1.1.1.27), lactoylglutathione lyase (LGL, EC 4.4.1.5), malate dehydrogenase (MDH, EC 1.1.1.37), mannose-6-phosphate isomerase (MPI, EC 5.3.1.8), dipeptidase (PEP-A, EC 3.4.13.?), tripeptide aminopeptidase (PEP-B, EC 3.4.11.?), dipeptidase (PEP-C, EC 3.4.13.?), proline dipeptidase (PEP-D, EC 3.4.13.?), phosphoglycerate mutase (PGAM, EC 5.4.2.1), phosphogluconate dehydrogenase (PGDH, EC 1.1.1.44), phosphoglycerate kinase (PGK, EC 2.7.2.3), phosphoglucomutase (PGM, EC 5.4.2.2), purine-nucleoside phosphorylase (PNP, EC 2.4.2.1), superoxide dismutase (SOD, EC 1.15.1.1), and triose-phosphate isomerase (TPI, EC 5.3.1.1).

We based our initial analysis of the allozyme data on the null hypothesis that all samples stemming from a single panmictic species, which predicts genotype frequencies will conform to Hardy-Weinberg expectations. We examined multi-locus genotypes of individual skinks from a single locality for the Wahlund effect, a deficiency of heterozygotes from that predicted under Hardy-Weinberg expectations due to a sample with two or more genetically differentiated populations. The presence of two or more species in sympatry is often evident from the presence of fixed allelic differences at one or more loci where the genotypic classes are concordant among individuals (see Richardson *et al.* [1986] for a more detailed explanation). When we observed evidence of departure from Hardy-Weinberg expectations at one or more loci, individuals classified according to these multi-locus genotypes were treated as a population. Where no evidence of departure from Hardy-Weinberg expectations was observed, we treated all of the individuals at each of these locations as a population. Given our null hypothesis, this meant that in some cases we pooled distinct locations in the absence of genetic differentiation between the samples. We expressed phenetic diversity among populations using the Unweighted Pair-Group (UPGMA, Sneath & Sokal 1973) method. We also made a preliminary assessment of the phylogenetic relationships of the populations studied using the Fitch-Margoliash method (Fitch & Margoliash 1967), based on Rogers' D, and a parsimony analysis, scoring the electromorphs using the method of Georges and Adams (1992). Software used for the analysis were the FITCH algorithm from Felsenstein's PHYLIP package, with input order randomised using the SHUFFL routine (25 passes), and the heuristic parsimony algorithm of Swofford's PAUP*.

Results

The allozyme data identified 15 genotypic populations from among the specimens identified as *C. u. orientalis*, with 10 additional populations identified among the outgroup species (Table 1). Figure 1 shows the UPGMA phenogram of the percentage fixed allelic differences between populations, while Fig. 2 shows a phylogenetic hypothesis for these populations based on the Fitch-Margoliash tree. The parsimony analysis produced the same topology.

The populations of *C. u. orientalis* fell into one of three clusters. Most belonged to two groups, one primarily southern and one primarily central, separated by a minimum of three fixed allelic differences at the *Adh*, *Dia* and *Pep-A* loci. A third group, is represented by the single specimen from Arrabury, Queensland which has a minimum of three fixed (or almost fixed) allelic differences at the *Acoh*, *Pep-B* and *Sod-1* loci compared with the other two groups. Our sampling is not adequate to examine geographic patterns of variation within each cluster but the presence of some within-group allelic variation suggests that future, more detailed sampling would yield useful information.

Ctenotus leonhardii, *C. regius*, and *C. septenarius*, also members of the *C. leonhardii* species group, were distinct from the three *C. u. orientalis* groups and from *C. strauchii varius*. Interspecific levels of genetic divergence within the *C. leonhardii* group ranged from an average

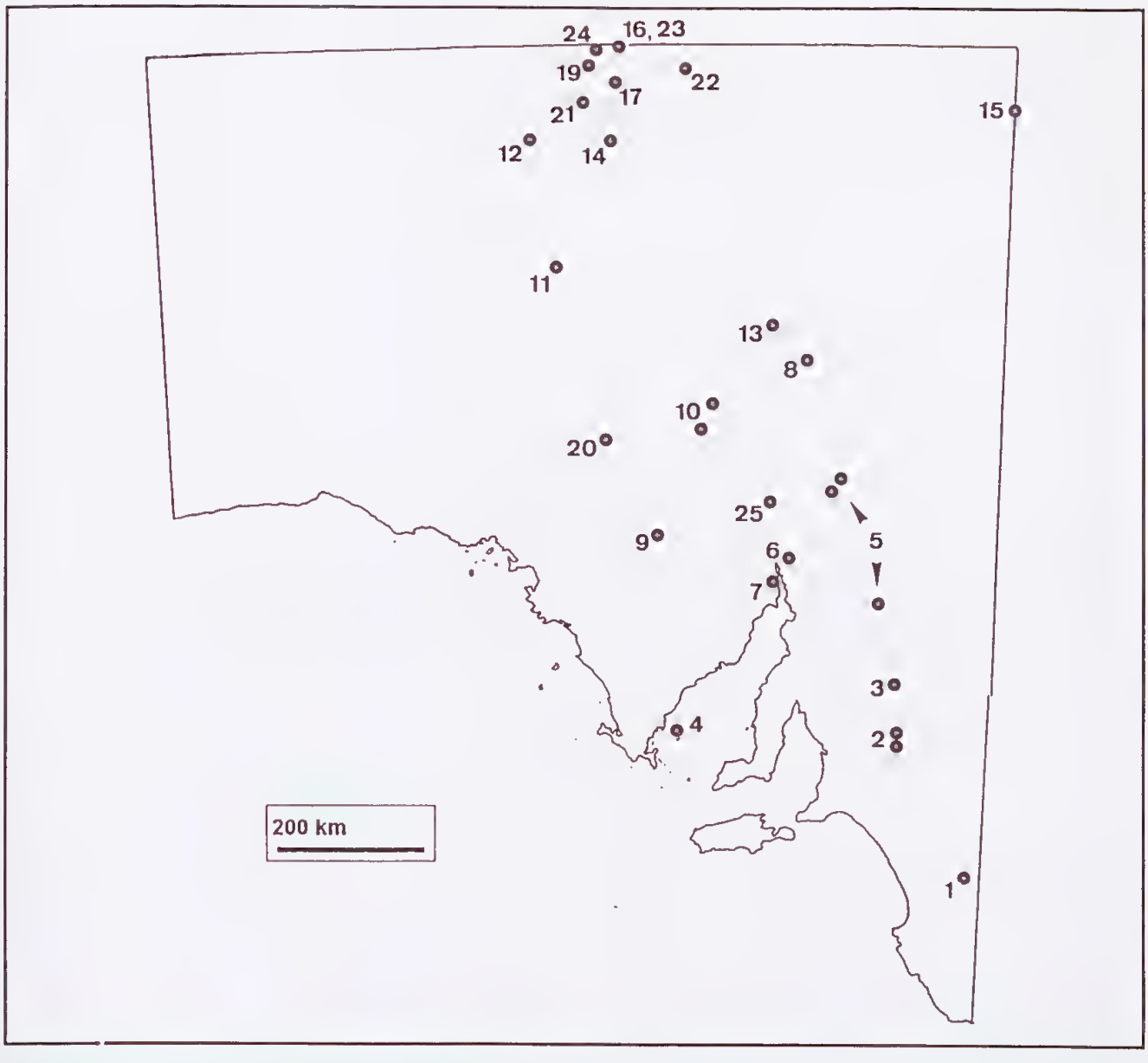

FIGURE 1. Map of South Australia showing the geographic origin of the populations sampled for allozyme data. See appendix for details of localities and specimens.

of 9% fixed differences between 'southern' and 'central' *C. u. orientalis* to 20% between *C. leonhardii* and the other species group members. As expected, *C. s. varius* was the most divergent taxon, with an average of 34% fixed allelic differences compared with any member of the *C. leonhardii* species group.

The three genetic groups within *C. u. orientalis* can be distinguished morphologically. The 'southern' group is identical to the holotype of *C. u. orientalis*. The pale dorsolateral stripe is prominent and continuous, the black laterodorsal stripes have straight medial edges and completely enclose single series of pale dots or short dashes and there is always a light-edged, black vertebral stripe. The lateral pattern consists of two to four series of small white dots, bordered below by a white midlateral stripe which is continuous posteriorly but which normally breaks up well before reaching the axilla.

The 'central' group has variable development of a light dorsolateral stripe and the black laterodorsal stripes are absent or ragged-edged medially; if a laterodorsal series of pale dots is present, the spots are not completely surrounded by blackish background colour, but contact the light laterodorsal region. The dorsum is usually metallic medium brown with a black vertebral stripe which lacks distinct pale edges. The lateral pattern is similar to that of the 'southern' group.

TABLE 1. Allele frequencies at 31 loci, expressed as a percentage, in 25 populations of *Ctenotus*. Alleles are designated alphabetically, with a being the most cathodally migrating allele. Where enzymes are encoded by more than one locus, the loci are designated numerically in order of increasing electrophoretic mobility. Where the allele frequencies are not given, the frequency is 100. The number of individuals sampled is indicated in parentheses. The following 11 loci were invariant: *Enol*, *Fdpase*, *Gapd*, *Gdh*, *Got-1*, *Gpi*, *Ldh-1*, *Mdh-1*, *Mpi*, *Np* and *Pgam*.

	Species 1						Species 2								Species 3	*septenarius*		*leonhardii*			*regius*			*strauchii*	
Locus	1 (1)	2 (5)	3 (1)	4 (5)	5 (3)	6 (1)	7 (1)	8 (1)	9 (4)	10 (4)	11 (1)	12 (1)	13 (1)	14 (1)	15 (1)	16 (5)	17 (1)	18 (1)	19 (2)	20 (1)	21 (2)	22 (1)	23 (1)	24 (3)	25 (1)
Acon	c	d(30) c(70)	c	d(30) c(70)	c	c	e(50) c(50)	c	c	d(50) c(50)	c	c	c	c	d	d(30) c(70)	c	d	d	d	b(25) a(75)	b(50) a(50)	c(50) b(50)	d(50) c(50)	c
Acp	b	b	b	b	b(83) a(17)	b	b	b	c(50) b(50)	b	b	b	b	b	b	b	b	b	c(25) b(75)	-	b	b	b	b	b
Acyc	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	-	a	a	a	b(17) a(83)	a
Adh	a	a	a	a	b(17) a(83)	a	c(50) b(50)	b	b	b	b	b	b	b	b	b	b	d(50) c(50)	d(50) c(50)	c	b	b	b	e(17) d(83)	d
Alb	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	a	a
Ca	a	b(10) a(90)	a	a	a	a	b(50) a(50)	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a
Dia	c	d(20) c(80)	c	c	c	c	b	b	b	b	b	b	b	b	c	a	a	b	b	b	b	b	b	e	f(50) e(50)
Est	b	b	b	b	b	b	b	b	b(75) a(25)	b(87) a(13)	b	b	b	b	b	c(10) b(90)	c(50) b(50)	b	c(25) b(75)	b	b	b	b	b	b
Fum	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	b	c
Glo	a	a	a	b(20) a(80)	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a
Got-2	a	a	a	a	b(17) a(83)	a	a	a	b(25) a(75)	a	a	a	a	a	b(50) a(50)	a	a	a	a	b(50) a(50)	a	a	a	a	a
G6pd	b	b(90) a(10)	b(50) a(50)	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b
Gpd	c	c(90) b(10)	c	c	c(83) b(17)	c	b	b	c(16) b(67) a(17)	c(12) b(88)	c(50) b(50)	c(50) b(50)	b	b	b	b	b	b	b	b	b	b	b	d(17) c(83)	c
Gpi	b	b	b	b	b	b	b	b(75) a(25)	b	b	b	b	b	b	b	b	b	b	b	b	b	b	a	a	a

Hbdh	b	d(10) b(90)	b	b	b	b	b(50) a(50)	b	b(87) a(13)	b	b	b	b	b	b	c	c	b	b	b	b	b	b	c	c
Idh-1	b	b	b	b(90) a(10)	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b
Idh-2	a	a	b(50) a(50)	a	a	a	a	a	a	a	a	a	a	a	a	b(20) a(80)	a	a	c(25) a(75)	a	a	a	a	a	a	a
Lap	a	a	a	a	a	a	a	a	b(25) a(75)	a	a	-	a	a	a	a	a	a	a	a	a	a	a	b	b	
Ldh-2	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	b	b(50) a(50)	a	a	a	a	a	a	
Mdh-2	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	c(20) b(80)	b	b	b	b	b	b	b	a	a	
PepA	d	d	f(50) d(50)	d	e(17) d(83)	d(50) c(50)	c(50) b(50)	b	c(37) b(63)	c(62) b(38)	c(50) b(50)	b	c	b	b	b	b	b(50) a(50)	b	b	d(25) c(75)	c	c	c(17) b(83)	b	
PepB	a	a	a	a	a	a	a	a	a	a	a	a	a	a	b	b	b	b	b	b	b	b	b	c(17) b(83)	b	
PepC	c	c(40) b(60)	d(50) b(50)	c(40) b(60)	c(33) b(67)	b	b	b	b	c(12) b(88)	b	b	b	b	b	b	b	a	a	a	c(50) b(50)	b	b	c	c	
PepD	d	d	d(50) c(50)	d	e(17) d(83)	d	d	d	d(87) c(13)	d	d	b	d	d(50) b(50)	b	a	a	e	f(75) e(25)	e	b	b	b	e(33) d(50) a(17)	d	
6Pgd	d	d(70) c(30)	d	d	d	f(50) d(50)	d(50) c(50)	d	d	e(12) d(75) a(13)	d	d	d	d	d	d	d(50) b(50)	d	d	d	d	d(50) a(50)	d	f(17) d(83)	d	
Pgk	a	a	a	a	a	a	b	b	b	a	a	a	b(50) a(50)	a	b	b	b	b	b	b	b	b	b	b	a	a	
Pgm	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	b(17) a(83)	a	
Sod-1	a	a	d(50) a(50)	a	a	a	a	a	a	a	a	a	a	a	c	b	b	c	c	c	c	c	c	a	a	
Sod-2	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	b	b	b	a	a	a	a	a	
Sordh	c	c(50) b(30) a(20)	c	c(20) b(30) a(50)	e(17) d(33) c(50)	c	c	d(50) c(50)	d(12) c(75) b(13)	h(12) f(50) d(25) c(13)	g	d	c	g	d	g(20) c(80)	g(50) c(50)	c	c	c	g	g	g	a	c(50) a(50)
Tpi	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	b	b	b	a	a

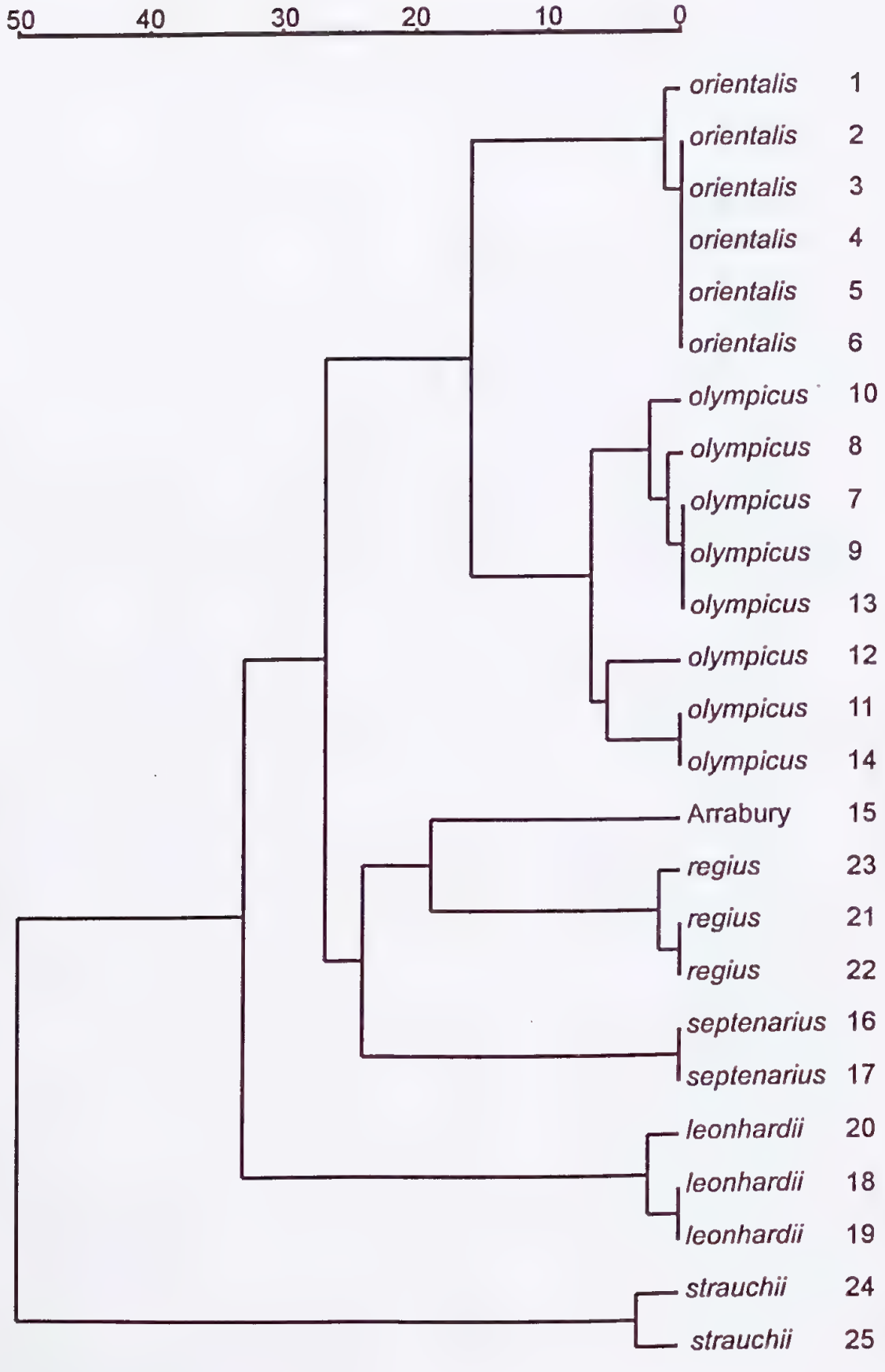

FIGURE 2. Phenogram of percentage fixed differences, constructed by UPGMA, for 25 populations of *Ctenotus* species.

The single specimen from Arrabury is heavily speckled dorsally and laterally, but with weakly contrasting dorsal stripes, the upper lateral and laterodorsal stripes being medium brown rather than blackish. The light dorsolateral stripe consists of dark-edged, light-centred scales and is indistinct due to the presence of other pale-centred scales which pattern the laterodorsal and upper lateral zones.

Two cases of syntopy are known, from the Flinders ranges (AMS R60053–54, 21 km S of Copley, P. Rankin & G. Husband, 22 January 1977) and the Olary Spur (SAMA R13156, R39266, near Oulnina homestead, R. Forsyth, 1 April 1972), and the distributions of the 'southern' and 'central' groups abut or overlap in the Gawler Ranges, Flinders Ranges and on the Olary Spur. There is no suggestion in the morphology or the allozyme data of clinal or other variation which might indicate genetic continuity between the two groups, while the groups maintain internal genetic uniformity over wide geographic ranges.

Typical *C. u. uber* was not available for electrophoretic comparisons, but it represents a fourth and highly distinctive morphological group, characterised by rufous rather than grey-brown dorsal colouring, different pattern details and longer tail (see also Storr 1971). *Ctenotus u. uber* itself encompasses considerable morphological variation. The ranges of *C. u. uber* and 'southern' group do not contact but no obviously intermediate specimens or populations are known. There seems to be no grounds for assuming, as Storr's taxonomy implied, that *uber* and *orientalis* are genetically continuous or even sister taxa.

At least three of the four taxa discussed here, *C. uber* and the 'southern' and 'central' groups of *C. u. orientalis* are species. The distinctive morphology, together with multiple concordant fixed allelic differences at allozyme loci (in the case of *C. u. orientalis*), and lack of intergradation indicate that reticulate evolution has ceased between populations of the different groups, which are therefore on their own evolutionary trajectories (Frost & Hillis 1990). The Arrabury specimen we leave indeterminate at present, as its taxonomic treatment will undoubtedly involve other poorly understood populations and nominal species from the eastern inland of Australia. Further work is also needed to address the taxonomic problems posed by the considerable variation that exists within Western Australian *C. uber*, including the status of *C. u. johnstonei*.

Taxonomy

All of the following species are members of the *Ctenotus leonhardii* species group, defined originally by Storr (1970) and subsequently modified by Storr *et al.* (1981) and King *et al.* (1988). The latter authors defined the C. *leonhardii* species group in part by two colouration characteristics, a predominance of reddish rather than olive pigmentation, and the replacement of black by dark brown pigmentation. Neither of these is true for all species; indeed, the second is scarcely true for any! In addition, the toes are said to be distinctive in being compressed, with subdigital lamellae tipped by obtuse keels or narrow to moderately wide calli. This characteristic is generally true for all species we have examined, but leaves considerable leeway for observer bias and confusion in applying the definition to particular specimens. Species groups, and more particularly phylogenetic groups, within *Ctenotus* need to be redefined as lineages rather than (as at present) being merely tools to simplify identification.

Ctenotus uber Storr, 1969

Ctenotus uber Storr, 1969, p. 102. Holotype: WAM R17654, 22 miles SE of Yalgoo, WA [approx. 28° 35' S, 116° 26' E].

Diagnosis

Ground colour of body reddish orange. Black vertebral stripe very narrow (occupying no more than the median one-quarter of each vertebral scale row) or absent. Laterodorsal dark brown to black stripes bearing a series of distinct pale spots. Original tail averages more than 200% of snout-vent length (SVL).

Description

Storr's (1969) description of scalation and proportions is not significantly altered by the larger sample now available for examination. Midbody scales in 28–33 rows, the mean of 30.2 (±1.19), based on a sample of 52 specimens, is very close to Storr's figure of 30.8. The value for relative tail length, reported by Storr to average 222% of SVL based on eight specimens, is comparable to the value of 216% (±44.6) obtained by us, based on Storr's specimens plus a further 27 specimens. Nasals almost always separated (frequency = 0.96). Prefrontals usually separated (frequency = 0.63). Storr's data (1971) suggested

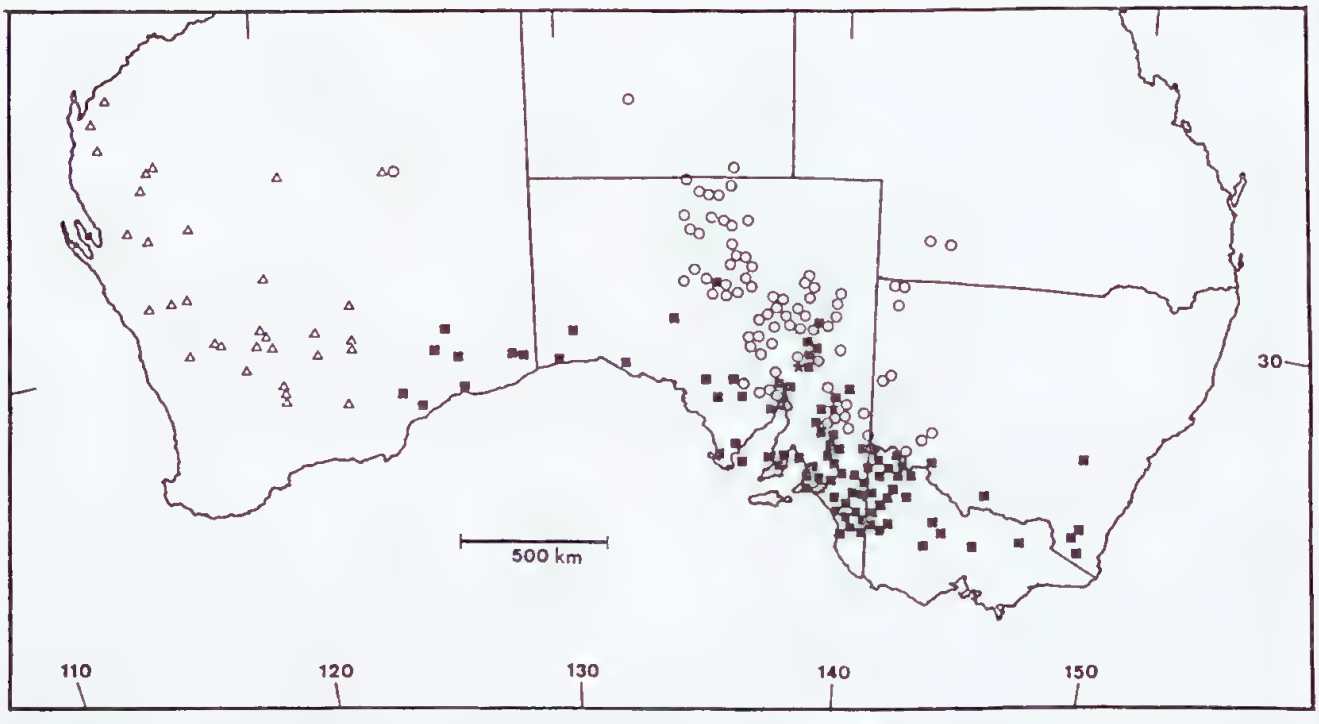

FIGURE 3. Geographic distributions of *Ctenotus uber* (Δ), *C. orientalis* (■) and *C. olympicus* (○). Stars indicate two instances of syntopy of *C. orientalis* and *C. olympicus*.

that loreal proportions could help differentiate *uber* and *orientalis*, but our measurements indicate that the two species are very similar in this respect; posterior loreal length/height ranges 0.8–1.6 in both species, and mean values are 1.2 (±0.17) for *C. uber* and 1.1 (±0.18) for *C. orientalis*.

Colour is medium reddish to orange brown on the dorsal surface of the head, limbs and tail. Laterodorsal and dorsolateral zones black, divided by a pale brown to whitish dorsolateral line. A narrow black vertebral stripe may be present or absent. Laterodorsal dark zone with a single longitudinal series of pale brown to whitish spots. Upper lateral zone demarcated ventrally by a midlateral white stripe beginning in the inguinal region, but breaking up anteriorly (about midway to forelimb) into a series of whitish spots. Upper lateral zone bearing several series of small whitish dots. Lower lateral zone variable, with irregular grey ventrolateral blotching or spotting.

Colour photograph in Storr *et al.* (1981).

Distribution

Western Australia, from the Exmouth Gulf area, south and east as far as the edge of the Nullarbor Plain. Southeastern limits roughly along the line connecting Mullewa–Lake Hillman–Parker Range–Norseman. Northeastern limit poorly defined but few specimens have been recorded northeast of a line connecting Dampier and Rawlinna.

Notes

Storr's type series included specimens now assigned to other species: *C. orientalis* (WAM R17268, R17284–85) from the Nullarbor Plain and *C. septenarius* (R20759) from the Rawlinson Range. Three specimens, from Mungilli Claypan (R26894–5) and 18 km E of Mungilli Claypan (R26897, i.e. the vicinity of Mt Johnston at the northern end of the Fame Range), are also not typical *C. uber* and are considered further in the 'Discussion' section below.

Ctenotus uber is mostly confined to the west and southwestern interior of Western Australia. There is marked geographic variation in colour pattern. The pattern which conforms most closely with Storr's original description is that of the holotype, in which the zone of dorsal ground colour along the vertebral region, which separates the laterodorsal zones, is narrow, occupying no more than half a paravertebral scale on each side, but almost always includes a dark vertebral stripe (sometimes fading on the posterior one-third of the dorsum). In south-central Western Australia, this 'median strip' of rufous colouring is often much wider, occupying up to one paravertebral

scale on each side, narrowing the laterodorsal zones so that the laterodorsal series of spots almost contact the middorsal colour, and there is usually little or no trace of a dark vertebral stripe posterior to the shoulder region. Northwestern specimens, from about the latitude of Shark Bay northwards, are generally paler with more pronounced spotting and less contrasting dorsolateral stripes.

Ctenotus orientalis Storr, 1971

Ctenotus uber orientalis Storr, 1971, p.8. Holotype: NMV D825, Ouyen, Victoria [35° 04' S, 142° 19' E].
Minervascincus monaro Wells and Wellington, 1985, p. 35. Holotype: AMS R92239, 6 km along Cambalong Rd, Bombala, New South Wales (36° 53' S, 149° 08' E).

Diagnosis

Ground colour of body beige to medium brown, without reddish tinge. Black to dark chocolate or dark reddish brown laterodorsal zone generally reduces exposure of the ground colour to a pair of paravertebral lines and a series of pale dots or dashes within each laterodorsal dark zone. Black to dark brown vertebral stripe always present and usually occupying about one-third of each vertebral scale row. A pale brown to white dorsolateral stripe always present and straight-edged.

Description

Storr's original description was based on few specimens and on a composite type series (see below). Examination of a series of 31 South Australian specimens results in the following redescription.

Midbody scales in 30–35 rows (mean 32.3±1.49). Nasals usually separated (frequency = 0.77). Prefrontals separated (frequency = 0.58) or in contact. Supraoculars 4, the first three in contact with the frontal. Supraciliaries 6–8, mode 7. Second (posterior) loreal 0.8–1.6 (mean 1.2) times as wide as high. Supralabials 8, with occasional asymmetric presence of 7 or 9. Ear lobules 4–6, variably shaped and proportioned, but generally obtusely pointed and with the second (from the top) the largest. Lamellae under fourth toe 20–27 (mean 23.9± 1.64), slightly to moderately compressed, each with a dark brown callus.

Adults (sexes similar): SVL (n = 26) 56–82 mm; hindlimb length (n = 26) 28–39 mm (41–57% SVL); tail length (n = 12) 109–158 mm (168–223% SVL, mean 171%±55.2).

Head, limbs and tail light grey-brown to tan. Body usually best described as black to dark brown with a pair of narrow, straight-edged pale brown paravertebral lines separating a dark vertebral stripe from the dark laterodorsal zones (Fig. 4A). The vertebral stripe occupies about one-third of each paravertebral scale row and terminates on the base of the tail. Each laterodorsal dark zone contains a single series of pale brown spots or short dashes. Light dorsolateral stripe well-developed, straight-edged. Upper lateral zone blackish, enclosing numerous small off-white dots, arranged roughly in two to four longitudinal series. A whitish midlateral stripe begins in the groin and runs anteriorly to about two-thirds of the axilla-groin distance, where it breaks up, becoming indistinguishable in the axillary region. Tail and limbs light grey-brown to yellowish-brown, the colour sometimes extending anteriorly along the posterior third of the back, between the vertebral and laterodorsal dark stripes. Dorsolateral dark zone extends along the tail as a dark brown lateral stripe. Ventral surface pearly white in life.

Colour photographs in Jenkins and Bartell (1980, p. 137), Knowles and Wilson (1988, fig. 413) and in Cogger (1996, p. 448).

Distribution

Southern semi-arid to dry temperate Australia from the Nullarbor Plain in Western Australia across southern South Australia (north to Anna Creek), through northwestern Victoria and the far south of New South Wales. Scattered populations extend further east into dry woodlands of the Great Dividing range in northeastern Victoria, southeastern New South Wales and the Australian Capital Territory.

Notes

Storr (1971) described *orientalis* as a subspecies of *uber*, presumably on the basis of the shared dorsal pattern of laterodorsal spots and heavily spotted flanks. Since then other spotted-backed *Ctenotus* have been recognised or redescribed, so that the shared colour pattern is no longer unique to these two species. We separately assessed morphological variation in a sample of 23 Western Australian *C. orientalis* to see if any trends suggested intergradation with *C. uber*. None was apparent. Western Australian *C. orientalis* are if anything more different from *C.*

uber in colour pattern than eastern *C. orientalis*, with less contrast between the light and dark hues, and the tail shorter (mean 166 % SVL, ± 8.4%, n = 9).

Peterson and Shea (1987) reassessed Peters' description of *Lygosoma schomburgkii*, redefined as *Ctenotus schomburgkii* by Storr (1969), which has a mixed syntype series, including both *schomburgkii* and *uber orientalis, sensu* Storr (1969, 1971). Peterson and Shea concluded that Peters' description applied strictly to the larger taxon, i.e. Storr's *uber orientalis*, which should therefore bear the name *schomburgkii* with nomination of a new lectotype. Storr (1987) in reply asserted that the description was more ambiguous than suggested by Peterson and Shea and that, in his opinion, Peters' description was composite. Peters' description of *schomburgkii* would most likely apply to Storr's *uber orientalis*, but Storr's notion of a composite type description by Peters remains reasonable; his usage as first reviser, and lectotype designation, is accepted here.

Storr's type series of *uber orientalis* is itself composite, including specimens now recognised as *orientalis* (NMV D00825, SAMA R0023–24, R01507, R05738, R10122), *olympicus* sp.nov. (SAMA R02789, R09466–69, R10017, R10027, R10030, R10044, R10055) and *septenarius* (SAMA R09735). Our redefined *C. orientalis* shows one major pattern of geographic variation, with most specimens from the Nullarbor Plain being markedly lighter coloured, with the laterodorsal and upper lateral zones being medium to dark reddish brown rather than black, reducing the contrast between the light and dark dorsal colours. Note that this variation does not imply intergradation with *C. uber*, as the rufous colouring of the latter species is confined to the lighter areas while upper lateral and laterodorsal colour is strongly contrasting black. Some southeastern Australian specimens have only a single series of rather large pale spots in the upper lateral zone and a more continuous midlateral stripe.

Minervascincus monaro Wells and Wellington, 1985 is based on a New South Wales specimen of *C. orientalis*. The authors provided no description of the holotype specimen or the species, nor any differential diagnostic data. They declared the species to be 'readily identified' by the photograph in Jenkins and Bartell (1980, p. 137), and that it was 'clearly evident' that the illustrated animal was not *C. uber*, but made no comparison with *C. orientalis*. Examination of both the holotype and the cited photograph shows the colour and pattern are completely concordant with typical *C. orientalis*, although the holotype specimen does have an unusually low midbody scale count of 28. It also has the less common condition of two other head scale attributes, nine supralabials and the nasals in contact.

Ctenotus orientalis occurs in a variety of warm-temperate to semi-arid woodland and heathland habitats, including open forest, woodland (including mallee) and low shrubland. It occurs patchily in the more heavily wooded areas, confining itself to especially dry or exposed microhabitats. It is syntopic with *C. robustus* through most of its range, but also occurs with *C. regius* in drier areas. From both it is distinguished by the presence of dorsal spotting and the incomplete pale lateral stripe. These lizards usually build their own burrows in sandy soil or under rocks.

Three specimens (AMS R59784–6) registered as *C. u. orientalis* from the western slopes of the Dividing Range in New South Wales, in the Cassilis area, are distinctive in colouration and from outside the range of typical *orientalis*. These are excluded from the distribution map, and for now their identification is left as indeterminate.

Ctenotus olympicus sp. nov.

Holotype: SAMA R20949, male, 48 km S of Olympic Dam, SA, 30° 48' S 136° 52' E.

Paratypes: 13 specimens from South Australia: SAMA R18620, approx. 20 km S of Port Augusta, 32° 38' S, 137° 35' E; R20936, Olympic Dam area, 30° 19' S, 136° 57' E; R20944–45, 48 km S of Olympic Dam, 30° 48' S, 136° 52' E; R25877, Witchelina Station, near homestead, 30° 01' S, 138° 03' E; R28203, 37 km N of Oodnadatta on road to Hamilton homestead, 27° 15' S, 135° 17' E; R28494, 118.5 km NE of Minnipa, 32° 15' S, 136° 14' E; R28503, 119.3 km NE of Minnipa, 32° 18' S, 136° 16' E; R28517, 115–120 km NE of Minnipa, 32° 20' S, 136° 17' E; R28543, 115 km NE of Minnipa, 32° 16' S, 136° 11' E; R30407, Breakaways Reserve, 25 km NNW of Coober Pedy, 28° 50' 40" S, 134° 41' 15" E; R35937, 95 km E of Marla, 27° 09' S, 134° 21' E; R36360, 1 km NE of Alberrie Creek, 29° 37' S, 137° 33' E.

The type series is restricted to the specimens used in the electrophoretic analysis.

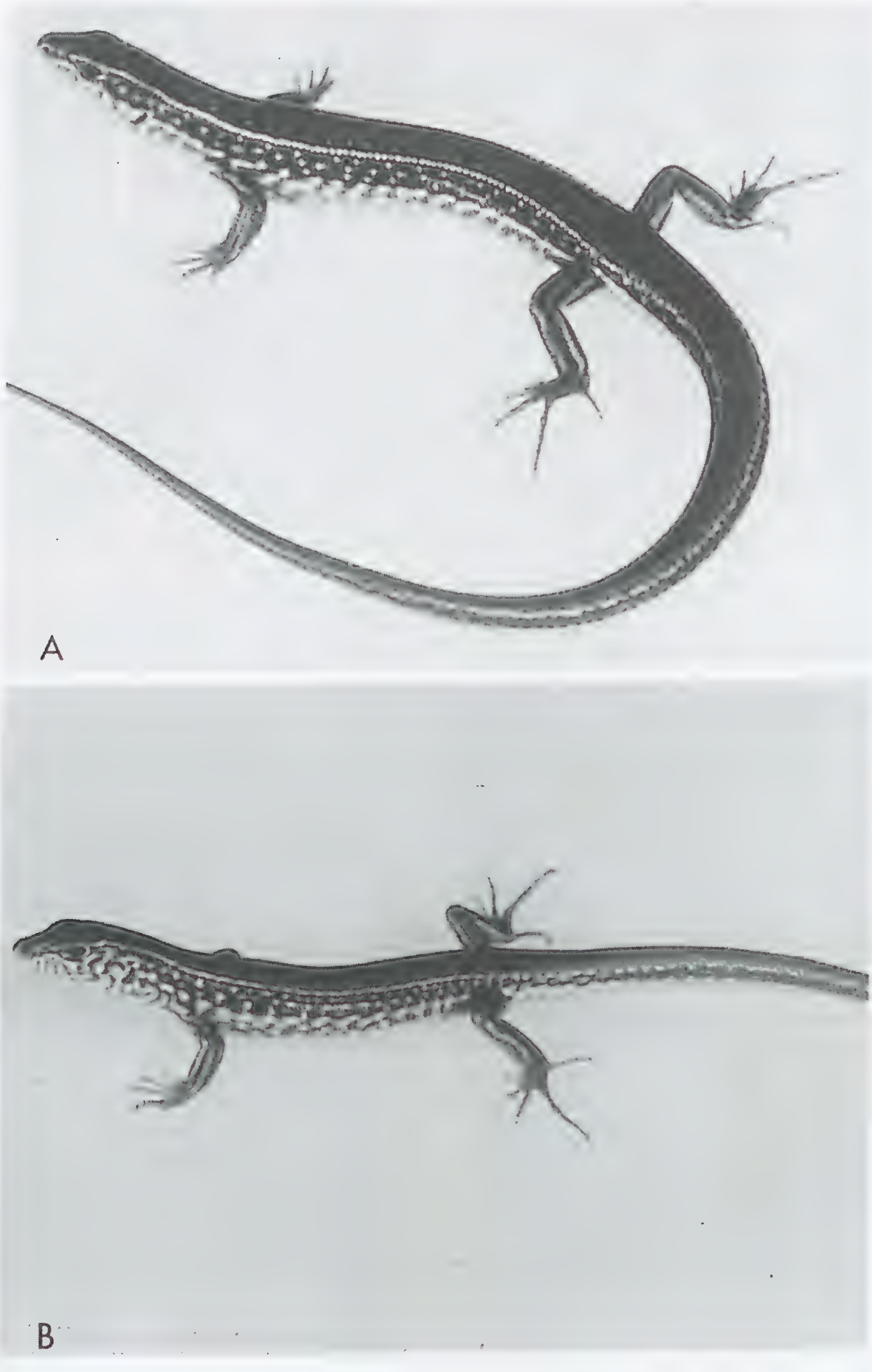

FIGURE 4. (A) *Ctenotus orientalis* from Whyalla, SA. (B) *C. olympicus* from the Davenport Range, SA. Photographs: T. Peters, SA Museum

Diagnosis

A member of the *C. leonhardii* species group with the dorsal ground colour pale beige to medium brown, often with a metallic lustre. Black vertebral stripe usually present, occupying no more than one-quarter of each paravertebral scale row and with very weak or no pale edging. Laterodorsal dark brown to black stripes, if present, with medial margins irregular, broken up by scattered lighter centred scales. Light dorsolateral line present or absent. Midlateral white stripe, if present, not extending anteriorly beyond midbody and often completely reduced to a zone of whitish spots. Size relatively small, SVL usually less than 70 mm; tail moderate (mean 187% SVL).

Description.

Based on type series (n = 14). Midbody scales in 28–32 rows (mean 30.9). Nasals usually separated (frequency = 0.64). Prefrontals usually in point to broad contact (frequency = 0.64) or separated. Supraoculars 4, the first three in contact with the frontal. Supraciliaries 7, rarely 6 or 8. Second loreal 0.8–1.6 (mean 1.2) times as wide as high. Supralabials 8, with occasional asymmetric presence of 7 or 9. Ear lobules 4–6, mostly obtusely pointed, the second or third (from the top) the largest. Lamellae under fourth toe 23–29 (mean 26.2), slightly to moderately compressed, each with a dark brown callus.

Adults (sexes similar; n = 13): SVL 52–69 mm; hindlimb length 26–35 mm (45–59% SVL); tail length (n = 11) 98–137 mm (170–211% SVL, mean 191%).

In preservative light brown, golden or medium brown dorsally. A narrow black vertebral stripe almost always present, occupying the corners of the paravertebral scale rows and no more than one-quarter of a paravertebral scale in width, runs from the nape to the base of the tail (Fig. 4B). This stripe sometimes poorly contrasting with dorsal colour and with no, or only a weakly contrasting, pale edge. A cream dorsolateral stripe, bordered medially by black, begins behind the supraciliaries. The posterior extent of this stripe is variable, sometimes continuing as far as the hips, but more often breaking into a zone of light and dark spots between forelimbs and hindlimbs. In specimens with a more continuous light dorsolateral stripe, the dark medial border (laterodorsal stripe) is usually narrow with a ragged medial edge. This stripe may include pale spots as in *C. orientalis* but in these cases the dorsolateral light stripe is often poorly defined posteriorly due to the adjacent dark areas being heavily speckled with whitish. Upper lateral zone blackish, with three to four longitudinal series of small, irregular pale spots. Upper lateral zone continues along the sides of the tail as a brown lateral stripe irregularly dotted with black. Lower border of upper lateral zone demarcated by a series of pale spots and dashes, sometimes forming an irregular midlateral stripe posteriorly. Lower lateral zone whitish irregularly smudged with grey. Ventral surface white. In life hind limbs and tail have a reddish tinge.

Examination of an additional 35 referred specimens in the SAMA collection indicates that the above counts and measurements are representative. In the larger sample, midbody scales averaged 30.4, frequency of separated nasals was 0.60 and of prefrontals in contact, 0.66. Maximum SVL was 75 mm (SAMA R03618, male, one of the paratypes of *C. u. orientalis*).

Etymology

Named for Olympic Dam, the type locality, but also in the spirit of the Greek mythological bent behind many *Ctenotus* specific epithets.

Distribution

Lake Eyre and Lake Torrens basins of central and northern South Australia, extending northwards into the southern NT and east and south through the northern Flinders Ranges to the Olary Plains of eastern South Australia and the adjacent west of New South Wales.

Notes

Three species of the *C. leonhardii* group are superficially similar to *C. olympicus* and are sympatric or parapatric through significant parts of its range. *Ctenotus orientalis* differs in having a pale margin to the black vertebral stripe and straight-edged black laterodorsal stripes completely enclosing a single series of pale dots or dashes. *Ctenotus septenarius* has a rusty orange dorsal colour with contrasting yellowish tail, multiple dark dorsal lines anteriorly and a well-developed midlateral stripe. *Ctenotus leonhardii* lacks laterodorsal pale spots, has a pale-edged vertebral stripe, straight-edged, light dorsolateral stripe and distinctive cheek and neck pattern of white spots on a purplish-brown background.

Most populations include a range of colour pattern variations, but plainer animals are more common in the west of the species' range while more heavily speckled animals are more common

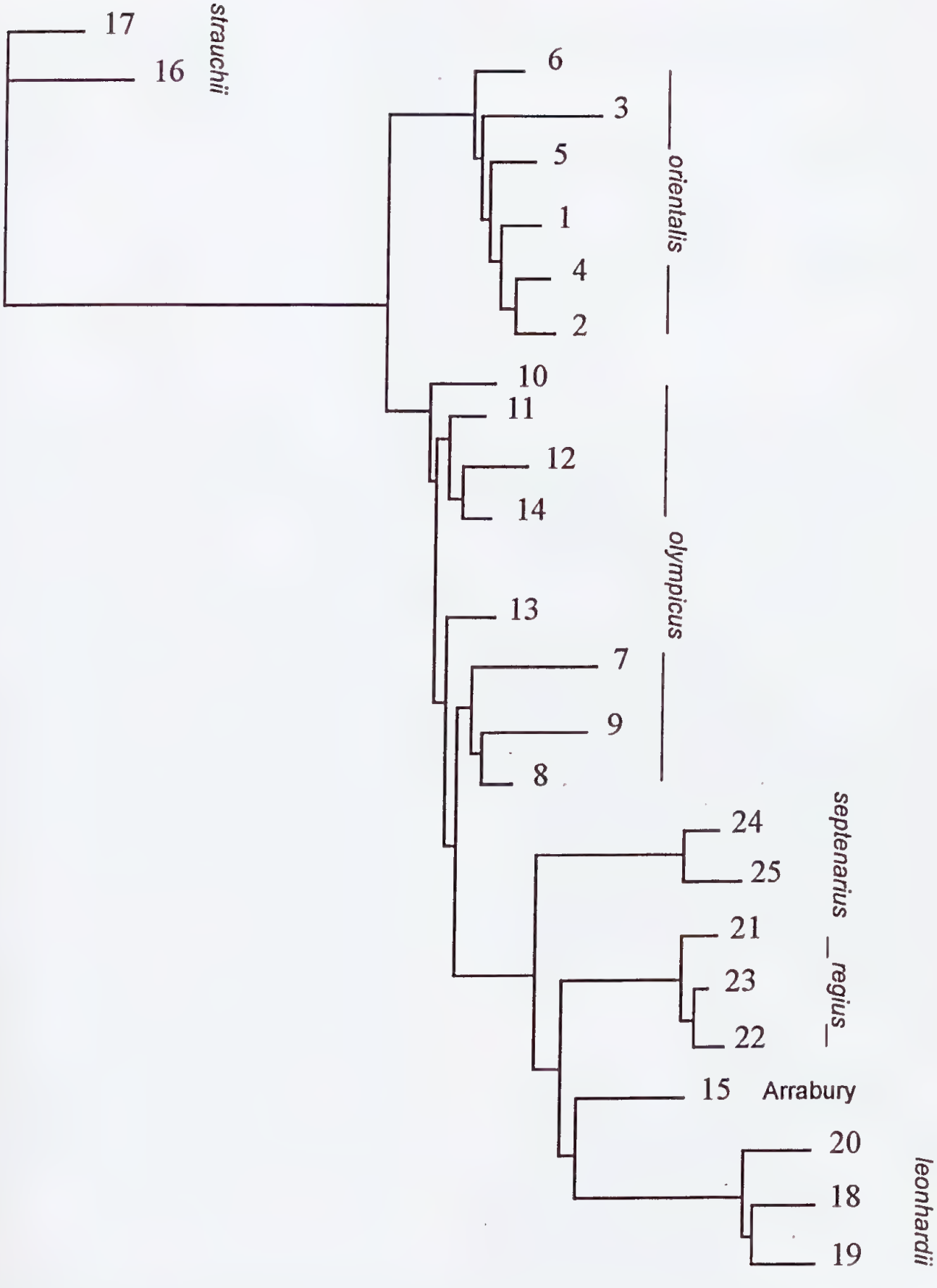

FIGURE 5. Phylogenetic relationships of 25 populations of *Ctenotus* skinks (analysis of Rogers' D using the FITCH algorithm from PHYLIP), showing paraphyly of *C. olympicus*. *Ctenotus strauchii* was designated as the outgroup to root relationships among the remaining species, all members of the *C. leonhardii* species group.

in the north. In the Flinders Ranges and the stony hills of the Olary Spur and Barrier Range, many specimens are much darker than elsewhere, with dorsal colour dark blackish brown, as in *C. orientalis*.

The most distinctive populations, included here with some reservation, are those from the northeastern limits of the species' range in northwest New South Wales and southwest Queensland. The five specimens examined (SAMA R10044, R36877, R36986, AMS R32604, R69731) are distinctively marked with black paravertebral and laterodorsal black lines or series of flecks on the nape and shoulders. Four of the five also have almost no trace of a light dorsolateral line, having only a zone of pale speckling. Henle (1996) also pointed out the difficulties of identifying specimens from this area, and of the variation within the similar southwestern Queensland species, *Ctenotus astarte*. However, his figured specimen is more like our unassigned 'Arrabury' specimen (and *C. astarte*) than the five assigned here to *C. olympicus*.

This species is found on heavy soils, generally with a stony component and a ground cover of chenopods. On plains, the species digs a burrow under a stone or bush. In the north of South Australia it occurs on and around gibber rises, sheltering in natural holes and spaces under rocks. Sometimes the only *Ctenotus* where it occurs, but often found with *C. strauchii varius*, *C. leonhardii*, *C. septenarius* and C. *saxatilis* in central and northern South Australia. Sadlier and Shea (1989) figure and describe the habitat of this species as *C. uber orientalis*. The photographs illustrating *C. uber* in Swan (1990, p. 96) and Ehmann (1993) also depict specimens of *C. olympicus*.

Discussion

Our revised taxa are species because they are diagnosable, show evidence (fixed allozyme differences) that reticulate evolution has ceased between them, and maintain their morphological distinctiveness in sympatry (Wiley 1981, Frost & Hillis 1990). We cannot demonstrate reciprocal monophyly of these species, however, so that one of the current species concepts, the Phylogenetic Species Concept (PSC, de Queiroz & Donoghue 1988; Echelle 1990), cannot be applied. Failure to establish strict monophyly of all species may be no more than we should expect if the prevailing allopatric and sympatric speciation models are true. Our experience of cryptic species in several taxa (Hutchinson & Donnellan 1992; Donnellan *et al.* 1993) suggests that it is common for differentiation to be achieved by frequency shifts in the states of shared characters or fixation of polymorphisms (applicable to both allozyme and external morphological data) rather than the acquisition by each species of evolutionary novelties.

The taxonomy of this complex is still far from final resolution. The restricted concept of *Ctenotus uber* adopted here still encompasses considerable variation and suggests that detailed study may reveal further cryptic species within this binomial. In eastern Western Australia, genetic study of populations assigned to *Ctenotus greeri*, *C. tanamiensis* and *C. uber* (including *C. u. johnstonei*) would help to unravel inter and intraspecific variation among these 'spotted-back' members of the *C. leonhardii* species group.

Three paratypes of *C. uber* from the vicinity of Mungilli Claypan (WAM R26894–95, R26897) all have the very long tail of *C. uber*, but R26897 is otherwise identical in colour to typical South Australian *C. olympicus*, while the other two are more like *C. uber* but have anomalous dorsal patterns, with relatively broad vertebral stripes and broad paravertebral zones of ground colour margining straight-edged laterodorsal stripes containing pale markings that run together to form ragged longitudinal pale lines. At present, we allocate R26897 to *C. olympicus* and retain the other two in *C. uber* but further collection in this area to examine the range of local variation will be necessary to clarify the status of these populations.

There are also several central and eastern-inland species, such as *Ctenotus aphrodite*, *C. astarte*, *C. hebetior*, *C. septenarius* and *C. serotinus* in which interpopulation variation is poorly understood and which may be closely related to *C. orientalis* and *C. uber*. One of these, *C. septenarius* is a more widespread and variable species than is indicated by the original description (King *et al.* 1988), and was included by Storr in the type series of both *C. uber* and *C. u. orientalis*. In the type series of *C. septenarius*, the dorsal colour pattern includes seven dark lines, a broad vertebral, a faint paravertebral and laterodorsal on each side and a wider dorsolateral. The two faint lines are the result of a single dark laterodorsal line on the nape developing a pale centre as it runs posteriorly but in many South Australian specimens the laterodorsal line does not fade as it runs back, so

that the resulting pattern consists of five bold dorsal lines, rather than three bold and four faint lines. Whatever the pattern it generally fades posteriorly, often reducing to three lines and then one (vertebral) on the posterior third of the back. A minority of specimens have only a vertebral line. *Ctenotus aphrodite* from southwest Queensland appears to be very similar to the single-lined pattern variant of *C. septenarius*, while some specimens of *C. astarte* and *C. serotinus* are similar to *C. olympicus* and to our distinctive Arrabury specimen. Future work should aim to sample these populations for biochemical or molecular systematic study.

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References

CRACRAFT, J. 1983. Species concepts and speciation analysis. Pp. 159–187 *in* Ed. R. F. Johnston 'Current Ornithology'. Vol. 1. Plenum Press: New York.

DE QUEIROZ, K. & DONOGHUE, M. J. 1988. Phylogenetic systematics and the species problem. *Cladistics* **4**: 317–338.

DONNELLAN, S., ADAMS, M., HUTCHINSON, M., & BAVERSTOCK, P. R. 1993. The identification of cryptic species in the Australian herpetofauna: a high research priority. Pp. 121–126 *in* 'Herpetology in Australia: A Diverse Discipline'. Eds D. Lunney & D. Ayres. Surrey Beatty & Sons with the Royal Zoological Society of New South Wales: Sydney.

ECHELLE, A. A. 1990. In defence of the phylogenetic species concept and the ontological status of hybridogenetic taxa. *Herpetologica* **46**: 109–113.

EHMANN, H. 1993. 'Encyclopaedia of Australian Animals. Reptiles'. The Australian Museum and Angus & Robertson: Sydney.

FITCH, H., & MARGOLIASH, E. 1967. Construction of phylogenetic trees. *Science* **155**: 279–284.

FROST, D. R., & HILLIS, D. M. 1990. Species in concept and practice: Herpetological applications. *Herpetologica* **46**: 87–104.

GEORGES, A., & ADAMS, M. 1992. A phylogeny for Australian chelid turtles based on allozyme electrophoresis. *Australian Journal of Zoology* **40**: 453–476.

GREER, A. E. 1982. A new species of *Leiolopisma* (Lacertilia: Scincidae) from Western Australia, with notes on the biology and relationships of other Australian species. *Records of the Australian Museum* **34**: 549–573.

HENLE, K. 1996. Herpetological observations in Sturt National Park, northwestern New South Wales, with a comment on *Ctenotus uber* and *C. astarte*. *Herpetofauna* **26**: 12–25.

HUTCHINSON, M. N. & DONNELLAN, S. C. 1992. Taxonomy and genetic variation in the Australian lizards of the genus *Pseudemoia* (Scincidae: Lygosominae). *Journal of Natural History* **26**: 215–264.

HUTCHINSON, M. N. & RAWLINSON, P. A. 1995. The water skinks (Lacertilia: *Eulamprus*) of Victoria and South Australia. *Records of the South Australian Museum* **28**: 185–207.

KING, M., HORNER, P., & FYFE, G. 1988. A new species of *Ctenotus* (Reptilia: Scincidae) from central Australia, and a key to the *Ctenotus leonhardii* species group. *The Beagle, Records of the Northern Territory Museum of Arts and Sciences* **5**: 147–153.

PETERSON, M. & SHEA, G. M. 1987. Reidentification of *Ctenotus schomburgkii* (Peters, 1864) (Lacertilia: Scincidae). *Transactions of the Royal Society of South Australia* **111**: 115–117.

RICHARDSON, B. J., BAVERSTOCK, P. R. & ADAMS, M. 1986. 'Allozyme Electrophoresis. A Handbook for Animal Systematics and Population Studies'. Academic Press: Sydney.

SADLIER, R. A. & SHEA, G. M. 1989. The reptiles of Mungo National Park and the Willandra Lakes region. *Herpetofauna* **19**: 9–27.

SNEATH, P. H. A. & SOKAL, R. 1973. 'Numerical Taxonomy'. W. H. Freeman: San Francisco.

STORR, G. M. 1969. The genus *Ctenotus* (Lacertilia: Scincidae) in the Eastern Division of Western Australia. *Journal and Proceedings of the Royal Society of Western Australia* **51**: 97–109.

STORR, G. M. 1970. The genus *Ctenotus* (Lacertilia: Scincidae) in the Northern Territory. *Journal and Proceedings of the Royal Society of Western Australia* **52**: 97–108.

STORR, G. M. 1971. The genus *Ctenotus* (Lacertilia: Scincidae) in South Australia. *Records of the South Australian Museum* **16**: 1–15.

STORR, G. M. 1980. A new *Lerista* and two new *Ctenotus* (Lacertilia: Scincidae) from Western Australia. *Records of the Western Australian Museum* **8**: 441–447.

STORR, G. M. 1987. On the identification of *Ctenotus schomburgkii* (Peters). *Transactions of the Royal Society of South Australia* **111**: 119.

STORR, G. M., SMITH, L. A. & JOHNSTONE, R. E. 1981. 'Lizards of Western Australia: 1: Skinks.' Western Australian Museum: Perth.

WILEY, E. O. 1981. 'Phylogenetics. The Theory and Practice of Phylogenetic Systematics'. John Wiley: New York.

Appendix

The following specimens were used in the electrophoretic study and scored for morphological data (all locations but one in South Australia).

Ctenotus orientalis. population 1: SAMA R27220, Hensley Scrub, 8 km NW of Bordertown; population 2: R26069–71, Swan Reach; R26164, R26166, Swan Reach Conservation Park; population 3: R26184, White Dam Conservation Park; population 4: R18275–79, Reevesby Island; population 5: R24797, Pitcairn Station; R24875, Ti Tree Well, Flinders Ranges; R24876, 'The Bunkers', Flinders Ranges; population 6: R25074, Stoney Creek.

Ctenotus olympicus. population 7: R18620, approx. 20 km S of Port Augusta; population 8: R25877, Witchelina Station, near homestead; population 9: R28494, R28503, R28517, R28543, 115–120 km NE of Minnipa; population 10: R20936, Olympic Dam area; R20944–45, R20949, 48 km S of Olympic Dam; population 11: R30407, Breakaways Reserve, 25 km NNW of Coober Pedy; population 12: R35937, 95 km E of Marla; population 13: R36360, 1 km NE of Alberrie Creek; population 14: R28203, 37 km N of Oodnadatta on road to Hamilton homestead.

Ctenotus sp. population 15: R20839, Arrabury Station, Qld.

Ctenotus septenarius. population 16: R35895–96, R35931–32, Finke River valley, Witjira National Park; population 17: R28214, Dalhousie ruins.

Ctenotus leonhardii. population 18: R35878, Finke River valley, Witjira National Park; population 19, R28244–45, 'Big Mill' area, Witjira National Park; population 20: R22246, Kingoonya.

Ctenotus regius. population 21: R35860, R35938: 1 km S of Hamilton homestead; population 22: R35915, Mokari, Witjira National Park; population 23: R35940, Finke River valley, Witjira National Park.

Ctenotus strauchii varius. population 24: R35887, 26 km ESE Mt Dare homestead, Witjira National Park; R35889–90, Mt Dare homestead metal dump; population 25: R34780, South Gap Station.

Additional specimens which provided scalation and mensural data.

Ctenotus uber. R17335, 24 km SSE of Karonie (Paratype); R17654, 35 km SSE Yalgoo (Holotype); R25118, Jiggalong (Paratype); R26894–95, Mungilli Claypan (Paratype); R30334, Koordarrie; R33967, 46 km S of Karalee; R36112, 18 km SW of Winning Pool; R40216, S of Carnarvon Ranges; R40537–38, R40539–42, Yinnietharra, Mica Well; R44246, 46 km NNE of Beacon; R47708, Weedarra, Gascoyne River; R48323, 48 km N of Beacon; R48402, 51 km N of Beacon; R49945, Wandagee; R54209, Tallering; R57692, Wilroy Reserve, 19 km S of Mullewa; R58155, 12 km NE of Dalwallinu; R58697, 13 km SE of Diemals; R62303, 5 km N of Jindabinbin rockhole; R63664, 25 km NNW of Winning HS; R64742, Mt Manning Ra.; R65814, 7.5 km NE of Comet Vale; R65910, 3 km NE of Mt Linden; R65976, 2.5 km [from] Mt Linden; R67017, 1.5 km S of Mt Jackson; R67133, 5 km N of Bungalbin Hill; R67983, Hell Gates, 37 km 87° from Dandaraga HS; R68889, 2 km N of Mt Narryer HS; R71822, 16.5 km 80° from Toomey Hills; R71824, 15 km 90° from Toomy Hills; R72017, 1.5 km W of Mt Jackson; R72201, R76231, 12 km NNE of Bungalbin Hill; R72584, near Comet Vale; R72645, 7.5 km NE of Comet Vale; R72733, 6.75 km NE of Comet Vale; R72792, 2.5 km N of Mt Linden; R73287, R73308, 7 km 238° from Black Flag; R73222, 2 km 97° from Yowie rockhole; R73373, 1 km 260° from Mt Manning Ra. (SE peak); R74400, Boorabbin; R76095, Mt Jackson Hill; R76119, 12 km SSW Mt Jackson Hill; R78517, 7 km WSW of Black Flag; R78541, 12 km WSW of Black Flag; R78700, 2 km NW of Mt Manning Ranges (SE peak); R78777, 16 km E of Toomey Hills; R78796, 15 km E of Toomey Hills; R78810, Boodarding Rock; R81301, Koordarrie HS; R81965, Chiddarcooping nature reserve; R82623, 15 km SSE of Mt Jackson; R84146, 17 km SSW of Muralgarra HS; R87655, 13 km SSW of Mt Phillip HS; R87758, 4 km NNE Mt Phillip HS; R91036, 9 km N of Yinnietharra.

Ctenotus olympicus. South Australia: SAMA R02789, R09466–69, Pernatty or South Gap Homestead (Paratypes of *Ctenotus uber orientalis*); R04314, Ediacara; R10017 (Paratype of *Ctenotus uber orientalis*); R10027, R10030, Mern Merna (Paratypes of *Ctenotus uber orientalis*); R12845, near Carrapateena Arm, Lake Torrens; R12846, Wirrappa Hills, 29 km SE of Woomera; R12847, Yarra Wurta cliff, north end of Lake Torrens; R13156 B, near Oulnina HS, Olary Ridge; R13912 8 km from Carriewerloo Woolshed on road to Illeroo; R14160 A–B, R14917 A–C, Waukaringa; R14932, Mern Merna; R15111, Disputed Creek; R15439, 10 km SW of Matin Wells Homestead; R16082, Mt Serle; R17789, Dutton Bluff, 17 km ESE of Bookaloo; R17799, Wooltana Station, 4–Mile Creek Bore; R19026–27, 10 km N of New Mulgaria Homestead; R19048, 15 km E of Frome Downs Homestead; R20039–40, Pimba; R21518, Moolawatana; R26828, 25 km S of Mabel Creek Homestead; R28403, 28 km NW of Iron Knob; R29072–73; 128 km ENE of Minnipa; R29083, 130.8 km ENE of Minnipa; R33282, 14 km W of Pimba.

WAM R64576, Pimba. Northern Territory: SAMA R10055. (Paratype of *Ctenotus uber orientalis*). New South Wales: SAMA R10044, Milparinka; WAM R92962, 2 km E of Mungo HS. Western Australia: WAM R26897, 18 km E of Mungilli Claypan (Paratype of *Ctenotus uber*)

Ctenotus orientalis. South Australia: SAMA R00023–24, Bowhill (Paratype); R03618, Lake Palankarinna (Paratype); R05738, Panaramitee Station (Paratype); R01507, Pinnaroo (Paratype); R10122, Blue Range Creek (Paratype); R11202, 1.6 km NE of Tea Tree Gully; R12718, Artimore Station; R12986, Reevesby Island; R14569, Marble Range, Eyre Peninsula; R15390, Wilpena Pound; R16225, Ninety Mile Desert; R18224, 6 km N of Cook; R18488, Reevesby Island; R20868, Stony Point; R21490, N end of Younghusband Peninsula; R24797, Pitcairn Stn; R26118–19, Reevesby Island; R28425, 37.5 km NE of Minnipa; R31453, Wardang Island; R35384, Reevesby Island. WAM R9863, Reevesby Island. New South Wales: AMS R92239, 6 km along Cambalong Rd, Bombala (Holotype of *Minervascincus monaro*).Victoria: NMV D00825, Ouyen (Holotype). Western Australia: WAM R17268, Forrest (Paratype of *Ctenotus uber*); R17284–85, Seemore Downs (Paratype of *Ctenotus uber*); R41592, 92 km NNE Rawlinna; R41593, 39 km S of Forrest; R41594, 24 km S of Forrest; R45615, 22 km N of Rawlinna; R77772, 32 km NW of Toolinna rockhole; R77777, 25 km N of Eyre Homestead; R91322, 3 km S of Haig; R91324, R91327, R91761, R91770, 7 km ESE Kilidwerinia Granite Rock; R91326, R91328, R92001, 16 km SSE of Haig; R91595, 18 km S of Haig; R91748, 13 km SSE of Haig; R91753–54, 1 km S of Haig; R91766, R91777, 5 km ESE Kilidwerinia Granite Rock; R91767, R91784, 15 km ESE Kilidwerinia Granite Rock; R92119, 50 km NE of Balladonia Hotel-Motel; R94707, Haig; R96723, 67 km N of Eucla.

Ctenotus septenarius. South Australia: SAM R09735, Dalhousie Homestead (Paratype of *Ctenotus uber orientalis*). Western Australia: WAM R20759, Pass of the Abencerrages, Rawlinson Range (Paratype of *Ctenotus uber*).

In addition, all specimens registered as *C. uber* from New South Wales, Victoria and Queensland in the NMV, SAMA and WAM collections (up to 1993), plus a large series from the AMS were examined and their identities revised and used to plot the distribution map (Fig. 3).

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CONTENTS PAGES

BAEHR, M. 123–126
A new species of the genus *Lestignathus* Erichson from Tasmania, with a note on the Tasmanian species of *Mecyclothorax* Sharp (Insecta: Coleoptera: Carabidae: Licininae, Psydrinae).

CORBETT, D. W. 49–70
A staunch but testing friendship: Douglas Mawson and T.W. Edgeworth David.

GENTILI, E. 101–122
The *Paracymus* of Australia (Coleoptera, Hydrophilidae).

JONES, P. G. 33–47
Words to objects: origins of ethnography in colonial South Australia.

KRISTENSEN, R. M. & MACKNESS, B. S. 73–87
First record of the marine tardigrade genus *Batillipes* (Arthrotardigrada: Batillipedidae) from South Australia with a description of a new species.

NELSON, R. C. 21–27
Why Flutes on Boomerangs and Throwing Sticks?

PRIDEAUX, G. J. 1–15
Simosthenurus newtonae sp. nov., a widespread sthenurine kangaroo (Diprotodontia: Macropodidae) from the Pleistocene of southern and eastern Australia.

WATTS, C. H. S. 29–31
Revision of Australian *Chaetarthria* Stephens (Coleoptera: Hydrophilidae)..

WATTS, C. H. S. 89–99
Three new species of *Tiporus* Watts (Coleoptera; Dytiscidae) with redescriptions of the other species in the genus.

WATTS, C. H. S. & HUMPHREYS, W. F. 127–144
Six new species of *Nirridessus* Watts and Humphreys and *Tjirtudessus* Watts and Humphreys (Coleoptera: Dytiscidae) from underground waters in Australia.

WATTS, C. H. S. & PINDER, A. 17–19
Two new species of *Antiporus* Sharp from Western Australia (Coleoptera: Dytiscidae).

ZEIDLER, W. 71–72
Note on the origin of freshwater crayfish occurring on Kangaroo Island, South Australia

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SIMOSTHENURUS NEWTONAE SP. NOV., A WIDESPREAD STHENURINE KANGAROO (DIPROTODONTIA: MACROPODIDAE) FROM THE PLEISTOCENE OF SOUTHERN AND EASTERN AUSTRALIA

GAVIN J. PRIDEAUX

PRIDEAUX, G. J. 2000. *Simosthenurus newtonae* sp. nov., a widespread sthenurine kangaroo (Diprotodontia: Macropodidae) from the Pleistocene of southern and eastern Australia. *Records of the South Australian Museum* 33(1): 1–15.

Simosthenurus newtonae sp. nov. is described from the Pleistocene of southern and eastern Australia. Its cranium is similar in size to *Simosthenurus occidentalis*, but is less brachycephalic and has a narrower, more elongate rostrum with a less inflated frontal region. The moderately high-crowned molars are distinctive among the species of *Simosthenurus*, because they bear very few to no fine enamel crenulations, and primary crests that bear strong contacts with cusp apices. In these respects, the molars resemble *Sthenurus andersoni* and *Hadronomas puckridgi*.

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Sthenurines were a diverse group of robust browsing kangaroos common throughout southern and eastern Australia in the Pleistocene. *Simosthenurus newtonae* sp. nov. represents the seventh new sthenurine described since 1992. Although uncommon in most assemblages, it is one of the more widely distributed sthenurines, occurring in 21 localities (Fig. 1). The description of this new species forms the subject of this paper. A review of the phylogenetic relationships, chronology, zoogeography and evolution of the sthenurine kangaroos is currently in preparation.

Materials And Methods

Specimens referable to *Simosthenurus newtonae* sp. nov. are housed in the vertebrate palaeontological collections of the following institutions: Australian Museum, Sydney (AM); South Australian Museum, Adelaide (SAM); Field Museum of Natural History, Chicago (FMNH); Flinders University of South Australia, Adelaide (FU); Museum of Victoria, Melbourne (NMV); Queensland Museum, Brisbane (QM); Queen Victoria Museum, Launceston (QVM); Western Australian Museum, Perth (WAM). Serial designation of the cheek dentition follows Flower (1867), Wilson and Hill (1897) and Luckett (1993), except that the third adult premolars are now recognised as the only second generation cheek teeth in marsupials (Cifelli *et al.* 1996; Luckett and Woolley 1996). Dental nomenclature follows Tedford and Woodburne (1987), Ride (1993) or is standard. Mensuration follows Tedford (1966) and Wells and Murray (1979). All measurements are in millimetres.

Systematics

Order DIPROTODONTIA Owen 1866

Superfamily MACROPODOIDEA Gray 1821

Family MACROPODIDAE Gray 1821

Subfamily STHENURINAE (Glauert 1926)

Genus *Simosthenurus* Tedford 1966

Simosthenurus newtonae sp. nov.
Sthenurus oreas DeVis (in part), 1895: 97.
Sthenurus atlas Glauert, 1912: 64.
Sthenurus andersoni Bartholomai (in part), 1963: 58, fig. 3.
Sthenurus sp. Lundelius, 1963: 77, fig. 2.
Sthenurus sp. cf. *S. gilli* Merrilees, 1965: 29–30.
Sthenurus andersoni Tedford (in part), 1966: 25.
Sthenurus sp. II Marcus, 1976: 71; 74, fig. 27c–d.
Simosthenurus sp. II Pledge, 1980: 137, table 3.
Sthenurus sp. Williams, 1980: 107, site 30.
Sthenurus sp. cf. *S. atlas* Williams, 1980: 107, site 37.

FIGURE 1. Localities yielding remains of *Simosthenurus newtonae* sp. nov. (black squares): 1, Tight Entrance Cave; 2, Balladonia; 3, Madura Cave; 4, Lindsay Hall Cave; 5, Curramulka Quarry; 6, Black Rock Gravel Pit; 7, Baldina Creek; 8, Comaum Forest Cave; 9, Haystall Cave; 10, Henschke's Fossil Cave; 11, SOS Cave; 12, Victoria Fossil Cave; 13, Goulden's Hole; 14, Green Waterhole Cave (*Type locality*); 15, Kilsby's Hole; 16, McEachern's Cave; 17, Scotchtown Cave; 18, Teapot Creek; 19, Kandos; 20, Wellington Caves; 21, Darling Downs. Triangles denote localities yielding *Simosthenurus occidentalis*.

Sthenurus sp. Lundelius & Turnbull, 1989: 2, 4, fig. 1a.
Simosthenurus sp. nov. Prideaux & Wells, 1994: 227.
Sthenurus 'P17250' McNamara, 1994: 111, 115.
Sthenurus 'P17250' Prideaux & Wells, 1997: 191, 194.

Holotype

SAM P17249–P17250, partial adult cranium, and fused left and right dentaries (Figs. 2, 3).

Type Locality

Green Waterhole Cave, a submerged cave near Tantanoola, southeastern South Australia. Faunal composition suggests a late Pleistocene age (Pledge 1980; Newton 1988).

Paratypes

FU 0227, near complete adult cranium; FU 0252, juvenile cranium devoid of occipital region; SAM P20255–P16632–P16633, partial adult cranium, incomplete left and right dentaries; SAM

P28969, near complete, but crushed adult cranium; FU 0179, right dentary. All paratypes are from the Fossil Chamber in Victoria Fossil Cave, Naracoorte, southeastern South Australia. This locality is considered to be late Pleistocene, but is probably older than 212 000 years (Wells *et al.* 1984; Ayliffe *et al.* 1998).

Referred Specimens

Victoria Fossil Cave, Naracoorte, SA: FU 0205, partial right juvenile dentary; FU 0226, right M_3; FU 0259, partial left juvenile dentary; FU 0293, partial left adult dentary; FU 0887, partial left juvenile maxilla; FU 1084, partial left juvenile maxilla; SAM P16550, partial juvenile cranium; SAM P20243, partial left adult maxilla; SAM P27631, left I_1, M_{1-2}; SAM P28149, partial left adult dentary; SAM P28478, right P_3; SAM P28479, right M_1, M_3; SAM P28518, left I_1; SAM P28671, left juvenile dentary; SAM P28996, left juvenile dentary; SAM P32533, left M_3; SAM P32541, left I_1; SAM P32542, left I_1, M_3; SAM P32545, partial right juvenile dentary.

Haystall Cave, Naracoorte, SA: SAM P36624, right dP_2.

Henschke's Fossil Cave, Naracoorte, SA: SAM P17837, partial left juvenile maxilla, right dP^2, right M^1; SAM P18554, right M^1 metaloph; SAM P34807, right P^3; SAM P34808, left P^3; SAM P34809, right P^3; SAM P34810, right P_3; SAM P34811, left P^3; SAM P38788, dP_{2-3}, P_3, M_{1-2}, right P_3, M_1; SAM P38789, left and right M^4; SAM P38790, left P_3; SAM P38791, right M_4; SAM P38792, left P^3; and SAM P unregistered, several loose teeth.

SOS Cave, Naracoorte, SA: SAM P33476, partial right adult maxilla.

Comaum Forest Cave, near Penola, SA: SAM P31967, fused left and right premaxillae and maxillae.

Goulden's Hole, near Mount Schank, SA: SAM P36620, right P^3; SAM P36621, left P_3; SAM

FIGURE 2. Right lateral view of partial cranium and dentaries of *Simosthenurus newtonae* sp. nov. holotype, SAM P17249 / P17250. Small gradations on scale bar are millimetres.

P36622, left M^1; SAM P38780, left M^4; SAM P38781, left M_4.

Kilsby's Hole, Mount Gambier, SA: SAM P38782, left P^3, SAM P38783, right lower molar, SAM P38784, left upper molar, SAM P38785, right dP_2.

Black Rock Gravel Pit, near Orroroo, SA: SAM P23166, left and right adult dentaries.

Baldina Creek, Burra, SA: SAM P21035, partial juvenile dentary.

Curramulka Quarry, Yorke Peninsula, SA: SAM P38786, right P^3, SAM P38787, right P_3.

McEachern's Cave, near Nelson, VIC: SAM P17319, partial right adult dentary; NMV P198434–P198438–P198440, left and right adult maxillae; NMV P198435–P198436, left and right adult maxilla; NMV P198439, partial left adult dentary; NMV P198449, partial left adult maxilla; NMV P198450, right P^3 in maxilla fragment.

Teapot Creek, Monaro Region, NSW: AM F unregistered, partial right adult dentary.

Wellington Caves, NSW: AM F18872, left P^3.

Kandos, NSW: AM F73721, partial left adult dentary.

Darling Downs, southeastern QLD: QM F2978, partial right adult maxilla.

Scotchtown Cave, near Smithton, TAS: QVM:1992:GFV:232, right M_3; QVM:1992:GFV:238, right M^3; QVM:1992:GFV:242, right M^1.

Madura Cave, Madura, WA: FMNH PM4356, right P_3.

Lindsay Hall Cave, near Madura, WA: WAM 92.12.3, right M^1; WAM 92.12.10, right M^3; WAM 00.1.1, partial right juvenile maxilla.

Balladonia Soak, near Balladonia, WA: WAM 63.11.2–63.11.3, right adult dentary.

Tight Entrance Cave, southwestern WA: WAM

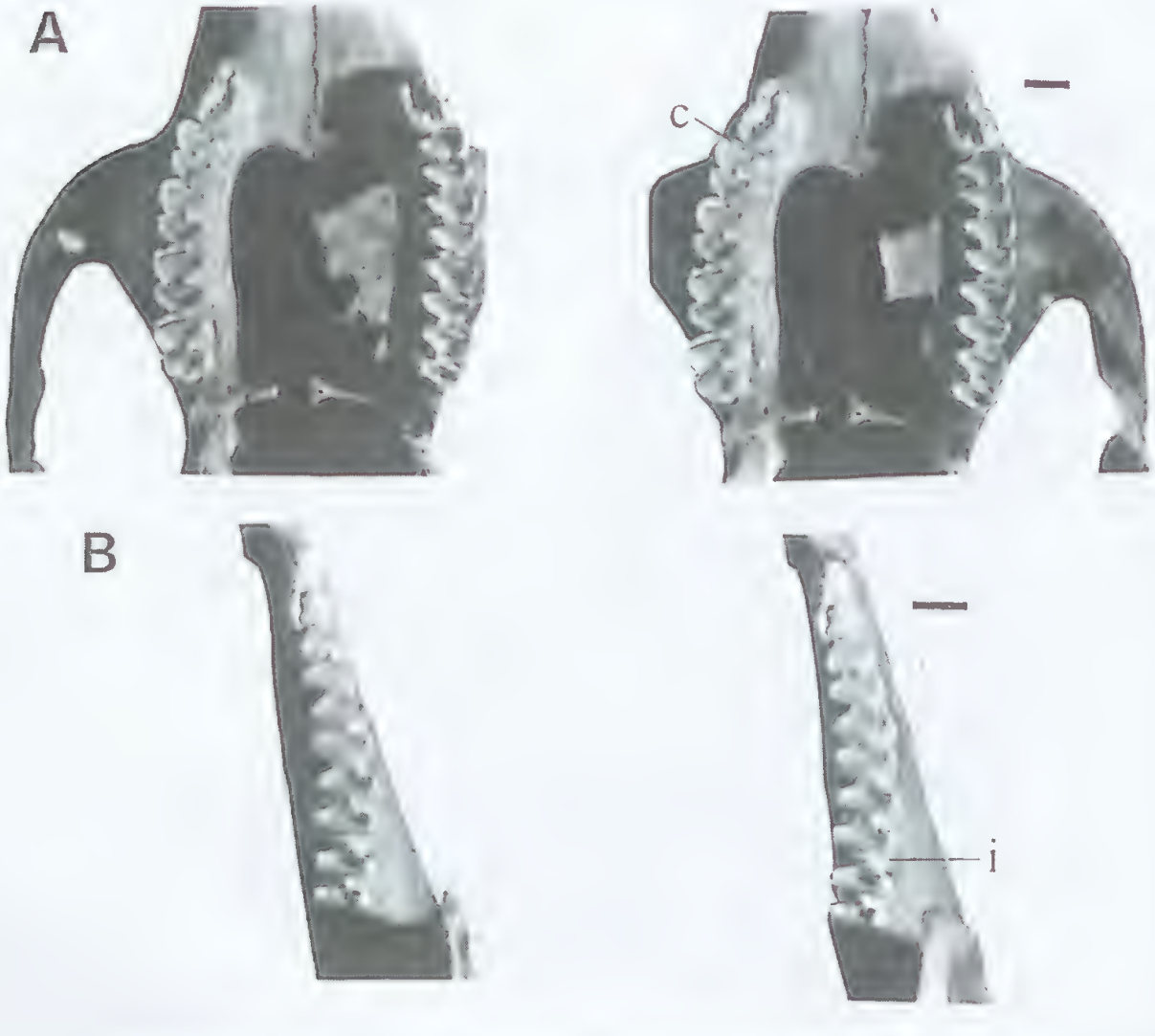

FIGURE 3. Palate and cheek dentitions of *Simosthenurus newtonae* sp. nov. holotype, SAM P17249 / P17250: A, palatal view (stereo); B, occlusal view of right lower cheek tooth row (stereo). Abbreviations: c, precingulum; i, inflation of posterior face of hypolophid. Scale bars = 10 millimetres.

97.5.312–97.5.314–97.5.314–99.11.142, left adult dentary.

Species Diagnosis

Cranium similar in size to *Simosthenurus brownei* Merrilees 1967 and *Si. occidentalis* Glauert 1910, but less brachycephalic, with narrower, more elongate rostrum, longer diastema and less inflated frontal region. Masseteric process short, narrowing distally and twisted posteriorly. P^3 short for width, crown inflated anterobuccally and thus only slightly wider posteriorly than anteriorly. Upper and lower molars relatively high-crowned with very few to no fine enamel crenulations. Crests on molars very well-developed, generally maintaining strong contact with cusp apices. Precingulum abruptly terminated at position of preprotocrista. Pterygoid fossa narrow and dorsoventrally deep. Lower molars bear pronounced anterior turn of lophid ends and strongly inflated posterior face of hypolophid.

Etymology

The new species is named after Cate A. Newton who studied the fossil fauna of Green Waterhole Cave and first recognised the morphological uniqueness of the holotype.

Description

Cranium (Figs 2–5; Table 1).

Premaxilla rather slender in lateral view, but flaring dorsally for extended contact with nasal. Incisor-bearing portion of premaxilla rather shallow and elongate (Fig. 5). Diastema moderately elongate, maxilla-premaxilla suture elongate and zigzagged. Cranial diastema deflected anteroventrally relative to cheek tooth row. Incisive foramina long with anterior border opposite or just posterior to posterior extremity of I^3 alveolus. Rostrum narrow, deep and elongate. Anteorbital/buccinator fossae on maxilla very shallow, resulting in reduced mesial curvature of diastema ridge, and rather flat-sided maxilla anteroventral to centre of orbit. Nasals long, broad posteriorly, narrowing anteriorly. One to three infraorbital foramina anterior to ventral border of orbit. Masseteric process short, moderately wide, flaring slightly towards distal end, twisted posteriorly under anterior portion of jugal (Figs 2–5). Process consists primarily of maxilla with only modest jugal contribution. Frontal region rather elongate in dorsal view, only moderately inflated laterally (Fig. 4A). Palatine vacuities extend anteriorly to opposite M^1 precingulum. Postpalatine bars form a thin bridge across palate opposite or posterior to M^4 metaloph (Fig. 3A).

Basicranial plane markedly elevated above palatal plane. Cranial pterygoid fossa wide and deep. Basioccipital slightly flexed posterodorsally relative to basisphenoid, and bears well-developed medial keel. Zygomatic arch deep, with a very wide ectoglenoid process at posterior extremity of jugal. Postglenoid process and glenoid fossa very large. Temporal crests not fully convergent on sagittal suture and only moderately developed. Occipital region broad, but not especially deep, and oriented at 90° relative to dorsal surface of neurocranium. Vertical medial occipital crest

TABLE 1. Mean dimensions of the adult cranium and dentary of *Simosthenurus newtonae* sp. nov. compared with the dimensions of the holotype (SAM P17249–P17250) and mean dimensions of *Simosthenurus occidentalis* and *Sthenurus andersoni*. Standard deviation is given in parentheses; sample size in brackets.

Dimension	*Simosthenurus newtonae*	Holo-type	*Simosthenurus occidentalis*	*Sthenurus andersoni*
Condylobasal Length	216 (3.0) [n=3]	–	198 (4.9) [n=4]	221 (8.5) [n=2]
Diastema Length	40.3 (1.04) [n=4]	–	31.8 (1.42) [n=4]	47.2 (4.38) [n=2]
% Diastema Length: Palatal Length	30.5 (0.85) [n=3]	–	25.2 (0.01) [n=4]	36.0 (2.83) [n=2]
Palatal Length	132 (1.2) [n=3]	–	126 (4.1) [n=4]	132 (2.1) [n=2]
Palatal Width between M^1 Protolophs	37.2 (2.27) [n=5]	39.0	35.0 (0.46) [n=3]	38.8 (0.92) [n=2]
Palatal Width between M^4 Protolophs	39.2 (4.05) [n=3]	43.1	41.2 (0.53) [n=3]	42.1 (0.14) [n=2]
Max. Width across Zygomatic Arches	132 (5.6) [n=4]	136	143 (1.53) [n=3]	114 (2.1) [n=2]
Maximum Width across Frontals	77.5 (3.05) [n=4]	82.0	91.8 (3.22) [n=4]	63.4 (1.98) [n=2]
Width across Paroccipital Processes	76.3 (5.12) [n=4]	82.0	67.7 (2.67) [n=3]	62.7 (3.25) [n=2]
Dentary Depth	34.8 (3.35) [n=5]	39.3	37.6 (1.70) [n=13]	28.4 (1.82) [n=10]
Dentary Width	20.5 (1.20) [n=5]	20.6	23.4 (2.03) [n=13]	17.2 (2.04) [n=10]
Dentary Depth / Width	1.70 (0.13) [n=5]	1.91	1.62 (0.14) [n=13]	1.65 (0.13) [n=10]

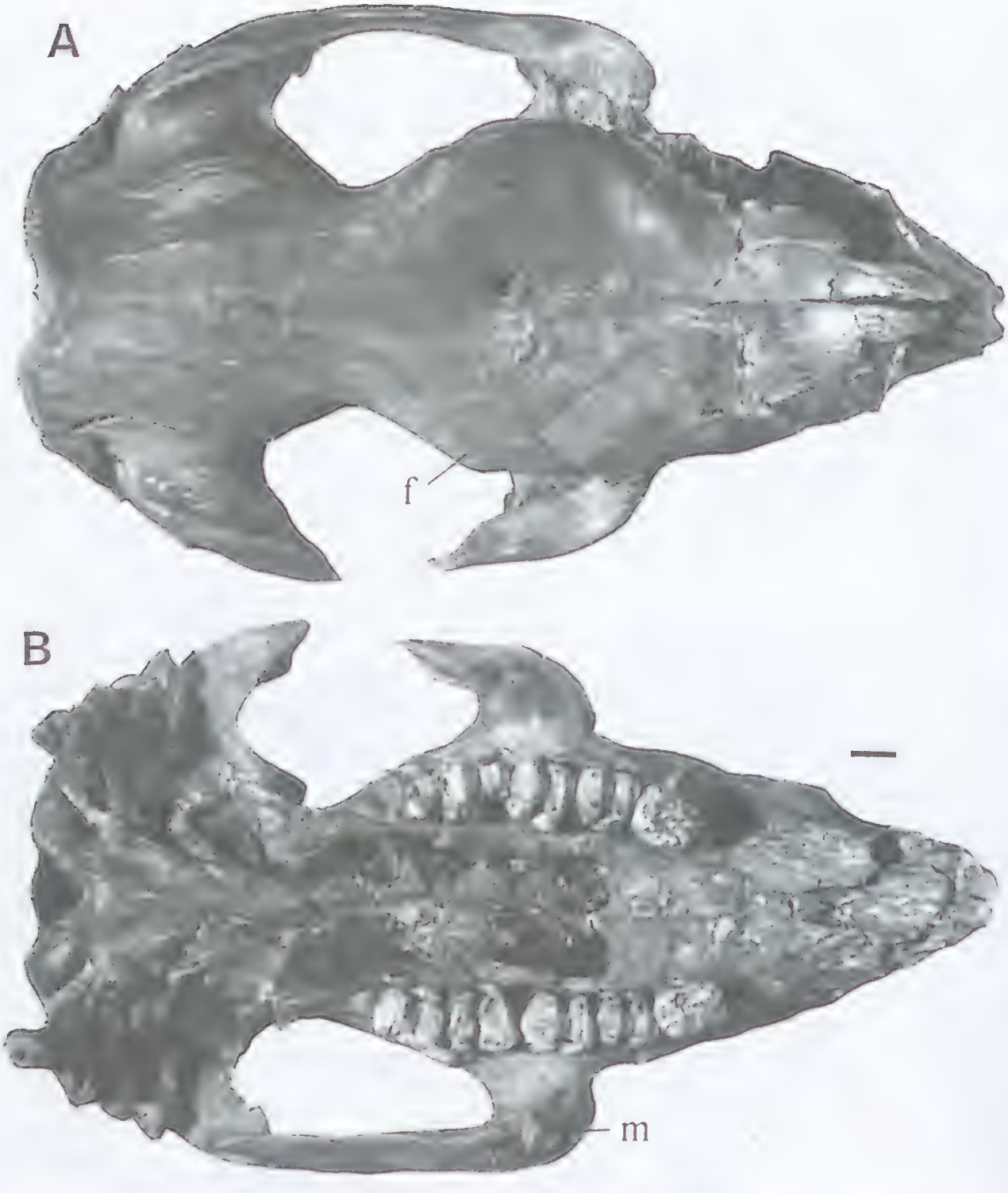

FIGURE 4. Cranium of *Simosthenurus newtonae* sp. nov. paratype, SAM P28969: **A**, dorsal view; **B**, palatal view. Abbreviations: f, frontal; m, masseteric process. Scale bar = 10 millimetres.

slight to well-developed, and leads ventrally to wide foramen magnum bordered by moderately large occipital condyles. Paroccipital processes deflected posteroventrally. Nuchal crests strongly-developed and extended posteriorly (Fig. 4A).

Upper Dentition (Figs 2–5; Table 2).

I^1 quite low in crown height and rather rounded in cross-section (Figs 4–5). Vertical occlusal facet faces posteriorly. Strongly curved anterior surface of crown extends forward well beyond anterior extremity of premaxilla. I^2 round in cross-section, one-third size of I^1. I^3 unknown, but alveolus suggests elongate crown.

Second upper deciduous premolar (dP^2) reminiscent of P^3 in general morphology, but

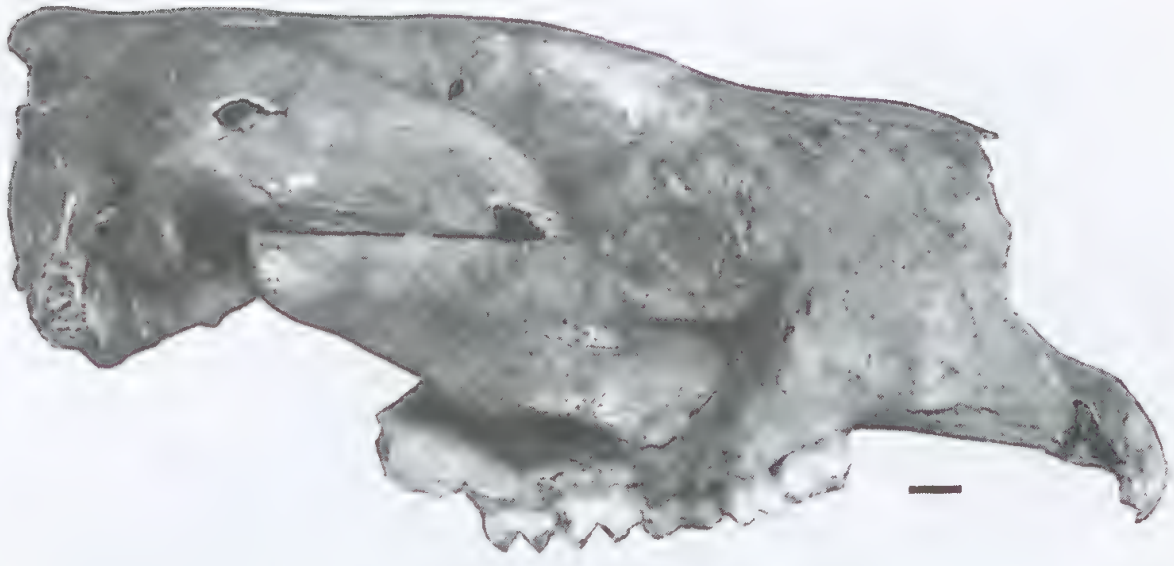

FIGURE 5. Right lateral view of partial cranium of *Simosthenurus newtonae* sp. nov. paratype, SAM P20255. Scale bar = 10 millimetres.

much shorter relative to width. Outline of tooth very rounded, especially on lingual side. Main crest straight and aligned with antero-posterior plane of tooth, lingual crest very curved and much lower in height than main crest. Anterior basin absent. Posterior basin well-developed, half size of longitudinal basin and separated by marked transverse ridge. Third upper deciduous premolar (dP^3) completely molariform, narrower across protoloph than metaloph and smaller than molars. Small precingulum restricted to buccal two-thirds of protoloph face, terminating at position of preprotocrista. Unworn crest of protoloph very convex anteriorly with very thick, united postparacrista and premetacrista. Remaining aspects very similar to molars, except for fine postlink and crest centred on posterior face of protoloph. P^3 usually short for width, only slightly wider posteriorly than anteriorly (Figs 3–5; Table 2). Outline rounded, with anterobuccal aspect strongly inflated and lingual side convex. Posterobuccal accessory cusp absent, poorly differentiated or slight, very occasionally with small, poorly differentiated cuspule anterior to it. Lingual crest lower and usually more curved than main crest. Anterior basin small and not well differentiated. Longitudinal basin short, of modest width and depth, and occupied by fine to coarse transverse ridgelets. Posterior basin well-developed, and separated from longitudinal basin by strong transverse ridge formed by two strong ridgelets united at tooth midline, or by buccally curved end of lingual crest.

Upper cheek tooth row moderately curved buccally, with P^3 turned in slightly relative to molars (Figs 3A, 4B). Upper molars sized $M^1<M^2<M^3>M^4$ (Figs 2–5; Table 2). Metaloph narrower relative to protoloph on M^4 than on M^{1-3}. Lophs moderately high-crowned, with unworn crests slightly convex anteriorly. Loph faces bear few very fine or no enamel crenulations. Preparacrista strongly developed, and maintains strong, direct contact with paracone apex. Precingulum smoothly confluent with preparacrista and terminates at tiny remnant of preprotocrista, after extending across two-thirds of anterior face of protoloph (Fig. 3A). Prominent postprotocrista ascends posterobuccally into interloph valley, but only extends onto base of metaloph face as very short, fine crest. Well-developed postparacrista and moderately developed premetacrista curve in lingually, their union forming a distinct notch. Posterior face of metaloph dominated by well-developed postmetaconulecrista, which curves buccally across approximately three-quarters of posterior face of metaloph to meet similarly-developed postmetacrista. Tiny cuspule positioned at union of postmetaconulecrista and postmetacrista most prominent on M^3, and probably represents stylar cusp E. Posterior face of metaloph markedly inflated above postmetaconulecrista, especially more buccally.

Dentary (Figs 2, 3, 6; Table 1).

Ramus deep for width, especially posteriorly due to large digastric eminence (Figs 2,6), which curves in mesially along ventral border. Digastric

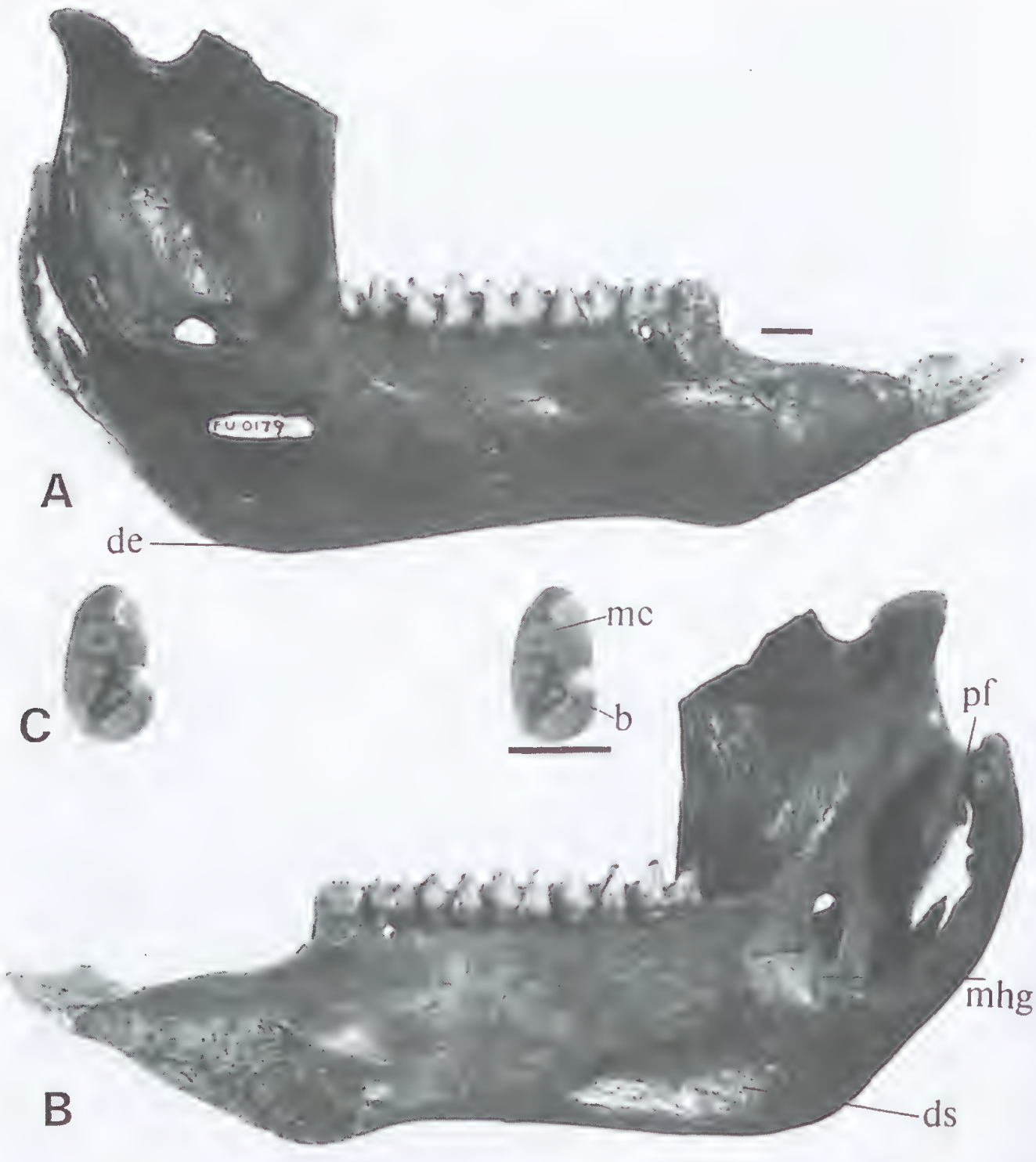

FIGURE 6. Right dentary of *Simosthenurus newtonae* sp. nov. paratype, FU 0179: **A**, lateral view; **B**, mesial view; **C**, occlusal view of excavated right P_3 (stereo). Abbreviations: b, buccal crest; de, digastric eminence; ds, digastric sulcus; mc, main crest; mhg, mylohyoid groove; pf, pterygoid fossa. Scale bars = 10 millimetres.

sulcus large and extends anteriorly to beneath M_2 hypolophid or M_3 protolophid (Fig. 6B). Dentary decreases in depth anteriorly, with diastema somewhat procumbent relative to cheek tooth row (Figs 2, 6). Symphysis rather slender and procumbent, with dorsal border parallel with alveolar margin of cheek tooth row. Posterior portion of symphysis underlies small genial pit, and only extends to beneath posterior root of P_3. Median dorsal groove deep and narrow. Anterior mental foramen located just anteroventral of buccinator sulcus. Buccinator sulcus shallow anteriorly, but gradually deepens posteriorly, terminating beneath M_1 hypolophid. Posterior

mental foramen mid-depth on ramus beneath M_2 hypolophid.

Ascending ramus rather short in lateral profile with anterior root located adjacent to M_4 hypolophid (Figs 2, 6). Anterior root forms buccal aspect of wide, deep postalveolar fossa. Masseteric foramen large and elliptical, leading into deep vertical masseteric canal which does not extend into body of ramus. Inferior mandibular foramen usually fairly large, with dorsal border at level of alveolar margin of cheek tooth row. Pterygoid fossa high and narrow, bearing pronounced upward projection of angular process (Figs 2, 6). Adjacent to ventral border of inferior mandibular foramen and at anterior extremity of pterygoid fossa, two sharp processes overhang mylohyoid groove; a posteroventrally-oriented process (cf. lingula in humans) and an anterodorsally-oriented process extending from anterior end of mesial border of pterygoid fossa (Fig. 6B). Mandibular condyle large.

Lower Dentition (Figs 2, 6; Table 2).

I_1 large, robust, elongate (Figs 2, 6). Occlusal surface slightly higher than, but oriented close to parallel with diastema. Level of I_1 occlusal surface well below level of cheek tooth occlusal surfaces. Second lower deciduous premolar (dP_2) similar in overall morphology to P_3, but shorter relative to width. Main crest runs obliquely across tooth from posterolingual corner to central position anteriorly. Short buccal crest trends buccally from posterior extremity of main crest, then curves anteriorly to run parallel to posterior part of main crest for short distance. Third lower deciduous premolar (dP_3) completely molariform, with protolophid slightly narrower than hypolophid and tapered markedly toward relatively narrow unworn crest. Small paraconid positioned at anterior extreme of trigonid, lingual to end of paracristid. Premetacristid runs posteriorly from paraconid, terminating midway up metaconid anterior face. Thick ?parametacristid descends smoothly from metaconid apex terminating in middle of trigonid basin. ?Preprotostylocristid runs anteriorly from topographic protoconid apex to point where paracristid turns lingually. Cristid obliqua strongly-developed, continuous with buccal extremity of hypolophid, meets protolophid slightly posterolingual and ventral to protoconid. Preentoconid low, curves from entoconid apex into interlophid valley to near midline of tooth. Very slight posterobuccally-accentuated inflation present on posterior face of hypolophid. Lophid faces lack enamel crenulations.

P_3 small and moderately short relative to molars, usually similar to or slightly shorter than M_3 in length (Figs 2, 3, 6; Table 2). Posterobuccal aspect of tooth inflated and bearing short, thick buccal crest separated from posterior end of main crest by very shallow, narrow median valley in holotype (Fig. 3B). In paratypes and referred specimens, inflation of posterobuccal corner less marked; buccal crest usually slightly longer and bears a thin, crescentic buccal crest separated from main crest by small and shallow median valley (Fig. 6C). Cuspules of main crest poorly differentiated posteriorly, but three usually distinguishable anteriorly. Very few to no ridgelets traverse median valley.

Lower cheek tooth row shows slight to moderate buccal curvature, with main crest of P_3 oriented slightly anterobuccally relative to molars (Fig. 3B). Moderately high-crowned lower molars sized $M_1<M_2<M_3>M_4$ (Figs 2, 3, 6, Table 2). Lophid faces often lack enamel crenulations, but a few very fine crenulations may be present on anterior faces. Anterior turn of lophid ends very pronounced (Fig. 3B). Paracristid and cristid obliqua well-developed, with former maintaining contact with topographic protoconid apex, and latter contacting or very close to hypoconid apex (Fig. 3B). Precingulid/trigonid shelf narrow and moderately short. Transverse (anterior) portion of paracristid broadly U-shaped in unworn teeth, curving out to anterior extremity of tooth, above precingulid, then posteriorly, usually uniting with fine, low premetacristid. ?Parametacristid either slight or absent. Cristid obliqua on minimally worn teeth divided into anterior and posterior components, although moderate wear produces one continuous crest. Lower posterior component curves smoothly anteriorly from hypoconid apex and terminates on buccal side of anterior component, located closer to midline of tooth and oriented less obliquely. Anterior component of cristid obliqua extremely slight anterior to interlophid valley, fining and terminating midway up posterior protolophid face. Preentoconid low and very slight. Shelf-like postcingulid absent, but buccal two-thirds of posterior aspect strongly inflated more ventrally, and overlapped by trigonid of succeeding molar (Figs 3B, 6A).

Intraspecific Variation

Cranium

There is very little variation in the general size and morphology of known adult crania that cannot be ascribed to differential preservation. The only noteworthy variation is a slight difference in

TABLE 2. Cheek tooth dimensions of *Simosthenurus newtonae* sp. nov., showing mean and standard deviation (in parentheses), dimensions of the holotype (SAM P17249–P17250), and the Wellington Caves and Kandos specimens (AM F18872, AM F73721).

Tooth	Length	Anterior Width	Posterior Width	Anterior Height	Posterior Height	Sample Size
UPPER DENTITION						
dP^2	10.3 (0.91)	7.7 (0.51)	9.6 (0.97)	7.1 (0.47)	7.8 (0.81)	3
dP^3	11.5 (0.20)	9.8 (0.66)	10.9 (0.42)	6.2 (0.85)	7.0 (1.15)	3
P^3						
Mean	16.6 (0.72)	10.5 (0.82)	12.3 (0.52)	10.4 (0.61)	10.1 (0.86)	15
Holotype	16.9	10.6	12.9	11.0	10.8	
AM F18872	18.3	10.0	13.4	10.3	9.8	
M^1						
Mean	13.2 (0.32)	12.9 (0.50)	12.6 (0.38)	7.7 (0.79)	7.9 (0.71)	11
Holotype	13.2	13.1	12.8	8.3	8.0	
M^2						
Mean	14.5 (0.60)	13.9 (0.82)	13.0 (0.65)	8.2 (0.71)	8.4 (0.71)	12
Holotype	14.7	13.7	13.0	9.0	8.7	
M^3						
Mean	15.0 (0.59)	13.7 (0.53)	12.9 (0.63)	7.9 (0.48)	7.9 (0.37)	12
Holotype	15.0	13.8	13.3	8.3	8.3	
M^4						
Mean	14.1 (0.67)	12.9 (0.36)	11.1 (0.42)	6.6 (0.55)	6.2 (0.52)	8
Holotype	14.8	13.0	11.5	7.5	6.6	
LOWER DENTITION						
dP_2	9.5 (0.68)	6.1 (0.49)	8.1 (0.31)	7.9 (0.95)	7.1 (0.83)	6
dP_3	10.4 (0.21)	8.3 (0.57)	8.8 (0.53)	7.1 (0.89)	7.2 (0.90)	6
P_3						
Mean	15.3 (0.74)	7.6 (0.43)	9.3 (0.33)	10.1 (0.79)	9.4 (1.16)	16
Holotype	15.3	7.7	9.7	10.0	10.1	
AM F73721	17.5	8.4	9.9	–	–	
M_1						
Mean	13.1 (0.67)	10.2 (0.37)	10.5 (0.35)	9.2 (0.98)	9.7 (1.47)	14
Holotype	13.1	10.1	10.7	9.1	9.7	
AM F73721	14.3	11.4	11.7	–	–	
M_2						
Mean	15.2 (0.61)	11.3 (0.38)	11.6 (0.34)	10.0 (1.38)	10.4 (1.35)	12
Holotype	15.7	11.5	11.7	9.2	9.6	
AM F73721	16.0	12.5	13.0	–	–	
M_3						
Mean	16.3 (0.45)	12.1 (0.29)	12.3 (0.42)	9.5 (1.43)	9.4 (1.25)	11
Holotype	16.6	12.1	12.4	9.5	9.5	
AM F73721	17.3	13.5	13.8	10.1	11.7	
M_4						
Mean	14.6 (0.79)	11.5 (0.28)	10.4 (0.44)	8.4 (0.74)	7.3 (0.55)	8
Holotype	15.8	11.3	10.7	8.6	7.3	
AM F73721	17.0	13.0	12.2	10.8	10.3	

zygomatic arch depth, with SAM P28969 shallower than SAM P17249, SAM P20255 and FU 0227.

The juvenile cranium, FU 0252 (dP^{2-3}, M^{1-2} erupted), clearly differs from the adult crania in proportion. The rostrum is relatively longer, the ventral orbital border of the jugal is less laterally expanded, the frontal region is less inflated, the temporal crests are less convergent upon one another, and the width across the zygomatic arches is comparatively less.

Upper Dentition

No appreciable variation is visible in I^1 size or morphology between the four specimens preserving that tooth. These same specimens also preserve I^2 but, in contrast to I^1, I^2 of SAM P20255 is slightly smaller in cross-sectional area than in the other specimens, even taking into consideration its greater degree of wear. Minimal size or morphological variation has been observed for dP^2, aside from the presence of an incipient posterobuccal accessory cusp in SAM P16550, a low, slight posterobuccal cingulum in FU 1084, and the complete absence of any such feature in FU 0252 and FU 1084. The longitudinal basin is slightly larger in FU 0252 than FU 1084, but SAM P16550 is too worn to determine. No notable size or morphological variation is visible in dP^3. Upper molar variation is also very limited, with the slightest fine enamel crenulations visible on the unworn molars of some specimens.

Marked variation exists in both size and morphology between the P^3 of the holotype, paratypes and referred specimens. Size differences are present in absolute length and width, crown height, and width relative to length, although no geographically-correlated size variation is evident. Morphological variation is displayed in: a) degree of posterobuccal accessory cusp development (ranging from clearly defined with small anterior cuspule, to poorly differentiated, to completely absent); b) degree of curvature of lingual crest and degree to which both crests are divided into cuspules; c) nature of coarse ridgelet separating posterior and longitudinal basins (composed of continuation of lingual crest or two transverse ridgelets); d) general inflation or roundness of tooth outline.

It is worth singling out a rather large, unworn P^3 from Wellington Caves (AM F18872) for special consideration, because it is much wider posteriorly than anteriorly. Although this conflicts with one of the defining characteristics of *Si. newtonae*, all other features of the tooth fit within the recognised *Si. newtonae* morphospace. These features include the inflation of the anterobuccal corner, shape of the lingual crest relative to the main crest, presence of one small cuspule immediately anterior to a poorly differentiated posterobuccal accessory cusp, and buccal curvature of the posterior end of the lingual crest, such that it partially separates the longitudinal and posterior basins. For these reasons, and because *Si. newtonae* is known from a dentary with rather large molars from nearby Kandos (AM F73721), I am confident that the Wellington Caves specimen is *Si. newtonae*.

Dentary

Few morphological differences are visible between the adult dentary specimens apart from slight variation in the posterior extent of the symphysis (beneath the anterior and posterior roots of P_3), and degree of development of the digastric eminence and sulcus. As a consequence of the latter variable feature, dentary depth varies slightly between specimens (e.g., compare the holotype dimensions with mean dimensions in Table 2). Variation is also present in the size of the inferior mandibular foramen and development of the processes overhanging the mylohyoid groove. Relatively, the holotype has the deepest dentary, largest inferior mandibular foramen and largest mylohyoid associated processes. Disregarding overall size differences, comparison of adult and juvenile specimens reveals a trend with age for increased dentary depth relative to width, and development of the digastric eminence and sulcus.

Lower Dentition.

No significant variation is visible in I_1 and dP_3. Similarly, there is little variation in dP_2, with only a slight difference between specimens in overall size, relative length of the buccal crest, and the variable presence of a ridgelet linking the anterior end of the buccal crest to the second cuspule of the main crest. While some size variation is evident in P_3, the considerable degree of morphological variation mirrors that observed in the P^3. Variation is displayed in: a) general tooth outline (rounded and gently narrowing anteriorly with minimal differentiation into anterior and posterior portions, posterobuccal corner inflated with much of buccal side and lingual side near parallel); b) shape of main crest (longitudinally straight, slightly sinusoidal); c) degree to which main crest cuspules are differentiated; d) relative length and shape of buccal crest (very short and

thick, short and crescentic); e) low, fine ridgelet connecting buccal crest to second cuspule of main crest (absent, present); f) width of median valley and degree of development of contained ridgelets. The P_3 also varies slightly in the degree to which its longitudinal axis is deflected anterobuccally relative to the curvature of the molar row. The minimal variation noted for the upper molars also holds for lower molars.

The Kandos dentary (AM F73721) varies slightly from typical *Si. newtonae*, because its P_3 and molars are around 10% larger. This is noteworthy in view of the marked similarity in dental size between specimens of *Si. newtonae* from across its wide range, which includes western and Tasmanian representatives. Although the dentition is considerably worn, no morphological differences are evident between the cheek teeth of AM F73721 and similarly worn specimens of *Si. newtonae*. While it is important to note that the digastric region, ascending ramus and anterior portion of the ramus are missing in AM F73721, the dentary of this specimen only differs from other individuals of *Si. newtonae* by possessing a buccinator sulcus that is slightly deeper anteriorly. In view of the marked variation in size observed within other *Simosthenurus* species (Prideaux 1999), I have very little hesitation in referring this specimen to *Si. newtonae*.

Comparison with other taxa

Cranium.

The cranium of *Simosthenurus newtonae* is more dolichocephalic than that of any other *Simosthenurus* species. In relative skull length it is intermediate between the other *Simosthenurus* species and *Sthenurus* Owen 1874, resembling *Hadronomas puckridgi* Woodburne 1967 in this regard. Among the species of *Simosthenurus*, the *Si. newtonae* cranium is most similar to *Si. occidentalis*, but it differs by having a more elongate rostrum and diastema, and a less posterodorsally-flexed basioccipital region. Despite the otherwise similar occipital and basicranial proportions of the two species, the direct effect of these differences is that the portion of the cranium posterior to the end of the maxilla is longer in *Si. newtonae* than it is in *Si. occidentalis*. Inflation of the frontal region and development of the supraorbital crests are less pronounced in *Si. newtonae* than in *Si. occidentalis* and *Si. brownei*, but greater than in *Si. gilli* Merrilees 1965 and *Si. baileyi* Prideaux and Wells 1998. The masseteric process is shorter and much narrower than *Si. occidentalis*, and is closest in morphology to *Si. maddocki* Wells and Murray 1979, but more twisted posteriorly. Moderate development of the temporal crests is similar to *Si. baileyi*. The shallow anteorbital/buccinator fossae and reduced mesial curvature of the diastema border resemble *Si. baileyi* as well as *Si. gilli*, but both of these species have much shorter rostra.

Upper Dentition.

The general shape of the *Si. newtonae* I^1 is typical of most *Simosthenurus* species, but the tooth is quite low-crowned, akin to that of *Si. brownei*. Although the elongate I^3 alveolus probably indicates a relatively elongate crown, I have observed no I^3 which may be confidently ascribed to *Si. newtonae*. The dP^2 of *Si. newtonae* is smaller than in southeastern *Si. brownei* and *Si. occidentalis*, but larger than in *Si. maddocki* and *Sthenurus andersoni* Marcus 1962. Morphologically, the tooth recalls *Si. brownei* and *Si. baileyi*, but it is less inflated posteriorly. Although quite variable in form, the P^3 of most *Si. newtonae* individuals is quite dissimilar to the other *Simosthenurus* species. This is especially so because, relative to its length, the tooth is usually quite wide anteriorly as well as posteriorly. The manner in which the posterior end of the lingual crest curves buccally to partially or wholly separate the longitudinal and posterior basins is only seen elsewhere in *S. andersoni*, as well as a P^3 fragment from the early Pliocene Bow Local Fauna of central eastern New South Wales (see Fig. 1A in Flannery and Archer 1984). Marked inflation of the anterobuccal corner of P^3 is only seen in rare individuals of other *Simosthenurus* species.

The upper molariform teeth of *Si. newtonae* are unique among *Simosthenurus*, and cannot readily be confused with any other species. They are similar to *Si. baileyi* in size, but are easily distinguished by being higher-crowned, lacking any noteworthy enamel crenulations, and having the primary crests strongly connected to cusp apices. The smaller *Si. gilli* and *Si. maddocki* upper molars bear some resemblance to *Si. newtonae* in this latter feature, as well as the curved nature of the postparacrista and premetacrista. However, all crests on the molars of *Si. maddocki* are more weakly developed than in *Si. newtonae*, while the majority of crests are more weakly developed in *Si. gilli*. The postprotocrista, which is divided into two components, and the better developed upper molar

midline crest of *Si. gilli* are the two exceptions. *Si. maddocki* may also be distinguished from *Si. newtonae* by the many very fine enamel crenulations that coat its loph surfaces. Overall, the molars of *Si. newtonae* are most similar to *S. andersoni*, but they differ by having the preparacrista much more strongly connected to the paracone apex, a stronger premetacrista, a stronger postmetaconulecrista and no continuation of the precingulum beyond the preprotocrista. Although a precingulum that does not extend lingually beyond the preprotocrista on the upper molars is unique to *Si. newtonae*, this condition is observed on the dP^3 of *S. andersoni*.

Dentary.

Si. newtonae is most similar in dentary size and morphology to *Si. brownei*, but the digastric eminence of the latter species is usually larger, as is the gradient of decreasing dentary depth anteriorly. In addition, the masseteric fossa is longer in *Si. brownei*, and the anterior root of the ascending ramus lies opposite the M_3–M_4 boundary or M_4 protolophid. In contrast, the anterior root in *Si. newtonae* leaves the ramus adjacent or just posterior to the M_4 hypolophid. The slightly procumbent diastema of *Si. newtonae* is not observed in any other *Simosthenurus* species, but is observed in *Sthenurus*, in *S. tindalei* Tedford 1966 and *S. stirlingi* Wells and Tedford 1995. The slender symphysis of *Si. newtonae* is most similar in size and form to that of *Si. brownei*, but it does not extend under the genial pit to the same degree, and its dorsal surface is nearly horizontal rather than anterodorsally-oriented. The narrow and deep median dorsal groove present in *Si. newtonae* is also characteristic of *Si. maddocki*.

Viewed posteriorly, the pterygoid fossa of *Si. newtonae* is narrower than in any other *Simosthenurus* species. Marked development of the processes overhanging the mylohyoid groove is similar to *Si. oreas* De Vis 1895, but the groove in the latter species is deeper and narrower.

Lower Dentition.

In size and morphology, the I_1 of *Si. newtonae* is intermediate in morphology between *Si. occidentalis* and *S. andersoni*. In this sense, the tooth resembles the I_1 of *Si. pales* De Vis 1895, but is much smaller. Size and general outline of the dP_2 is similar to *Si. occidentalis*, but the tooth is relatively narrower anteriorly. The shortness of the buccal crest is similar to that observed in *Si. maddocki*, but the dP_2 of this species is narrower and the main crest cuspules are more distinct. As with the P^3, the anterior width of P_3 is not markedly exceeded by the posterior width of the tooth. Overall, *Si. newtonae* is particular similar to *Si. brachyselenis* Prideaux and Wells 1997 in size and general morphology, but differs by being longer relative to the molars and having a slightly longer buccal crest. While the P_3 of the *Si. newtonae* holotype is similar in outline to that of *Si. brachyselenis*, other specimens of *Si. newtonae* often narrow more gradually anteriorly. Compared with '*Simosthenurus*' *cegsai* Pledge 1992, the *Si. newtonae* P_3 is more inflated posterobuccally, the median valley is usually wider, and the buccal crest is longer.

Although the protolophid base of the *Si. newtonae* dP_3 is narrower than the hypolophid base, the unworn crest of the protolophid is much narrower, similar to that of *Si. pales*. *Si. newtonae* appears to retain a paraconid lingual to the paracristid in the anterolingual corner of the dP_3 trigonid. A similar cusp is often observed on the dP_3 of other sthenurines, such as *Si. gilli*, *S. atlas* (Owen 1838) and *Hadronomas puckridgi*. Aside primarily from the stronger connection between the cristid obliqua and hypoconid apex, morphology of the *Si. newtonae* dP_3 is very similar to the succeeding molars. Among the species of *Simosthenurus*, the morphology of the *Si. newtonae* lower molars is quite unique. In some respects, their form more closely resembles species of *Sthenurus*, most especially *S. andersoni*. Similarities include the paucity of enamel crenulations on the lophid faces, the proximity of the paracristid and cristid obliqua to the buccal cusp apices, and the anterior turn of the lophid ends. Within *Simosthenurus*, the *Si. newtonae* lower molars most resemble *Si. gilli* in crown height and paucity of enamel crenulations, but are easily distinguished by their larger size, markedly inflated posterior face of the hypolophid, more curved transverse portion of the paracristid, and thicker, more buccally situated paracristid and cristid obliqua. A curved transverse portion of the paracristid is also observed in *Si. euryskaphus* Prideaux and Wells 1997 and many specimens of *Si. occidentalis*, but the paracristid and cristid obliqua of these two species are shifted more lingually, the lophid faces bear distinct fine enamel crenulations, and the lophid ends are less markedly turned anteriorly. In this latter feature and in the marked posterior inflation of the hypolophid, *Si. newtonae* is easily distinguished from all other *Simosthenurus* species.

Geographic Distribution

Simosthenurus newtonae is one of the most widely distributed Pleistocene sthenurine species. Overall, its distribution pattern most closely resembles that of *Si. occidentalis* (Fig. 1). Both species occur in late Pleistocene cave deposits in southwestern Australia (Merrilees 1979; Gully 1997), and were probably distributed across the southern periphery of the continent during periods when woodland or forest was more extensive. However, of these two species, only *Si. newtonae* has so far been recorded from Balladonia (= *Sthenurus atlas* in Glauert 1912) and the Nullarbor Plain (Lundelius, 1963; Lundelius and Turnbull 1989; Prideaux 1994; Aplin *et al.* 1995). Conversely, only *Si. occidentalis* is known from the Eyre Peninsula.

Remains of *Si. newtonae* and *Si. occidentalis* are commonly encountered in the cave faunas of southeastern South Australia (eg., Pledge, 1980; Wells *et al.*, 1984), although the latter species is much better known in Victoria. Together, they represent the only sthenurines known from late Pleistocene cave deposits in Tasmania, where *Si. occidentalis* is again by far the more abundant (Murray and Goede 1977; Goede and Murray 1979). While *Si. newtonae* is also known from southeastern Queensland (= *S. andersoni* in Bartholomai 1963), its only other occurrence north of the Monaro region in southeastern New South Wales is in the form of a large-toothed variant in the Kandos and Wellington Caves deposits.

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References

APLIN, K., BAYNES, A., HATCHER, L. M. & PRIDEAUX, G. J. 1995. Lindsay Hall Cave: a recently discovered southern Nullarbor Pleistocene site. *Abstracts of the 5th Conference on Australasian Vertebrate Evolution, Palaeontology and Systematics* p. 27.

AYLIFFE, L. K., MARIANELLI, P. C., MORIARTY, K. C., WELLS, R. T., MCCULLOCH, M. T., MORTIMER, G. E. & HELLSTROM, J. C. 1998. 500 ka precipitation record from southeastern Australia: evidence for interglacial relative aridity. *Geology* **26**: 147–150.

BARTHOLOMAI, A. 1963. Revision of the extinct macropodid genus *Sthenurus* Owen in Queensland. *Memoirs of the Queensland Museum* **14**: 51–76.

CIFELLI, R. L., ROWE, T. B., LUCKETT, W. P., BANTA, J., REYES, R. & HOWES, R. I. 1996. Fossil evidence for the origin of the marsupial pattern of tooth replacement. *Nature* **379**: 715–718.

DE VIS, C. W. 1895. A review of the fossil jaws of the Macropodidae in the Queensland Museum. *Proceedings of the Linnean Society of New South Wales* **10**: 75–133.

FLANNERY, T. F. & ARCHER, M. 1984. The macropodoids (Marsupialia) of the early Pliocene Bow Local Fauna, central eastern New South Wales. *The Australian Zoologist* **21**: 357–383.

FLOWER, W. H. 1867. On the development and succession of teeth in the Marsupialia. *Philosophical Transactions of the Royal Society* **157**: 631–641.

GLAUERT, L. 1912. Fossil marsupial remains from Balladonia in the Eucla Division. *Records of the Western Australian Museum and Art Gallery* **1**: 47–65.

GOEDE, A. & MURRAY, P. F. 1979. Late Pleistocene bone deposits from a cave in the Florentine Valley, Tasmania. *Papers and Proceedings of the Royal Society of Tasmania* **113**: 39–52.

GULLY, G. A. 1997. *Tight Entrance Cave, south-western Australia: a new megafaunal site and its palaeoclimatic and biogeographic implications.* Unpubl. B.Sc. (Hons) Thesis, School of Biological Sciences, Flinders University of South Australia, Adelaide.

LUCKETT, W. P. 1993. An ontogenetic assessment of dental homologies in therian mammals. Pp. 182–204 *In* 'Mammal Phylogeny'. Eds F. S. Szalay, M. J. Novacek & M. C. McKenna. Springer-Verlag: New York.

LUCKETT, W. P. & WOOLLEY, P. A. 1996. Ontogeny and homology of the dentition in dasyurid marsupials: development in *Sminthopsis virginiae*. *Journal of Mammalian Evolution* **3**: 327–364.

LUNDELIUS, E. L., Jr. 1963. Vertebrate remains from the Nullarbor Caves, Western Australia. *Journal of the Royal Society of Western Australia* **46**: 75–80.

LUNDELIUS, E. L., Jr. & TURNBULL, W. D. 1989. The mammalian fauna of Madura Cave, Western Australia Part VII: Macropodidae: Sthenurinae, Macropodinae, with a review of the marsupial portion of the fauna. *Fieldiana, Geology*, new series **17**: 1–71.

MARCUS, L. F. 1976. The Bingara fauna. A Pleistocene vertebrate fauna from Murchison County, New South Wales, Australia. *University of California Publications in Geological Sciences* **114**: 1–145.

MCNAMARA, J. A. 1994. A new fossil wallaby (Marsupialia; Macropodidae) from the south east of South Australia. *Records of the South Australian Museum* **27**: 111–115.

MERRILEES, D. 1965. Two species of the extinct genus *Sthenurus* Owen (Marsupialia, Macropodidae) from south-eastern South Australia, including *Sthenurus gilli* sp. nov. *Journal of the Royal Society of Western Australia* **48**: 22–32.

MERRILEES, D. 1979. The prehistoric environment in Western Australia. *Journal of the Royal Society of Western Australia* **62**: 109–128.

MURRAY, P. F. & GOEDE, A. 1977. Pleistocene vertebrate remains from a cave near Montagu, N.W. Tasmania. *Records of the Queen Victoria Museum* **60**: 1–29.

NEWTON, C. A. 1988. *A taphonomic and palaeoecological analysis of the Green Waterhole (5L81), a submerged Late Pleistocene bone deposit in the lower southeast of South Australia.* Unpubl. B.Sc. (Hons) Thesis, School of Biological Sciences, Flinders University of South Australia, Adelaide.

PLEDGE, N. S. 1980. Macropodid skeletons, including *Simosthenurus* Tedford, from an unusual "drowned cave" deposit in the south east of South Australia. *Records of the South Australian Museum* **18**: 131–141.

PRIDEAUX, G. J. 1994. A small sthenurine kangaroo from a Pleistocene cave deposit, Nullarbor Plain, Western Australia. *Transactions of the Royal Society of South Australia* **118**: 133–138.

PRIDEAUX, G. J. 1999. *Systematics and evolution of the extinct kangaroo subfamily, Sthenurinae*. Unpubl. Ph.D. Thesis, School of Biological Sciences, Flinders University of South Australia, Adelaide (2 Vols).

PRIDEAUX, G. J. & WELLS, R. T. 1994. A new extinct sthenurine kangaroo (Marsupiala [sic], Macropodidae) from southeastern Australia. *Records of the South Australian Museum* **27**: 227.

PRIDEAUX, G. J. & WELLS, R. T. 1997. New *Sthenurus* species (Macropodidae, Diprotodontia) from Wellington Caves and Bingara, New South Wales. *Proceedings of the Linnean Society of New South Wales* **117**: 181–196.

PRIDEAUX, G. J. & WELLS, R. T. 1998. *Sthenurus baileyi* sp. nov., a new fossil kangaroo from the Pleistocene of southern Australia. *Transactions of the Royal Society of South Australia* **122**: 1–15.

RIDE, W. D. L. 1993. *Jackmahoneya* gen. nov. and the genesis of the macropodiform molar. *Memoirs of the Association of Australasian Palaeontologists* **15**: 441–459.

TEDFORD, R. H. 1966. A review of the macropodid genus *Sthenurus*. *University of California Publications in Geological Sciences* **57**: 1–72.

TEDFORD, R. H. & WOODBURNE, M. O. 1987. The Ilariidae, a new family of vombatiform marsupials from Miocene strata of South Australia and an evaluation of the homology of molar cusps in the Diprotodontia. Pp. 401–418 *In* 'Possums and Opossums: Studies in Evolution'. Ed. M. Archer. Surrey Beatty & Sons and the Royal Zoological Society of New South Wales: Sydney.

WELLS, R. T. & MURRAY, P. F. 1979. A new sthenurine kangaroo (Marsupialia, Macropodidae) from southeastern South Australia. *Transactions of the Royal Society of South Australia* **103**: 213–219.

WELLS, R. T., MORIARTY, K. & WILLIAMS, D. L. G. 1984. The fossil vertebrate deposits of Victoria Fossil Cave Naracoorte: an introduction to the geology and fauna. *The Australian Zoologist* **21**: 305–333.

WILLIAMS, D. L. G. 1980. Catalogue of Pleistocene vertebrate fossils and sites in South Australia. *Transactions of the Royal Society of South Australia* **104**: 101–115.

WILSON, J. T. & HILL, J. P. 1897. Observations on the development and succession of the teeth in *Perameles*. *Quarterly Journal of Microscopic Science* **39**: 427–588.

TWO NEW SPECIES OF *ANTIPORUS* SHARP FROM WESTERN AUSTRALIA (COLEOPTERA: DYTISCIDAE)

C. H. S. WATTS AND A. PINDER

WATTS, C. H. S. and PINDER, A. 2000. Two new species of *Antiporus* from Western Australia (Coleoptera: Dytiscidae). *Records of the South Australian Museum* 33(1): 17–19.

Two new species of *Antiporus* Sharp, *A. pennifoldae* and *A. mcraeae*, are described from the south-west of Western Australia. Both species appear to be restricted to an area threatened by rising salinity.

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Two new species of *Antiporus* Sharp have recently been identified from the south-west of Western Australia. These were among material collected in a biological survey of wetlands in the wheatbelt and adjacent areas by the Department of Conservation and Land Management (CALM). The survey is part of the department's response to problems (particularly salinity and waterlogging) associated with rising groundwater in the region as a consequence of extensive clearing of native vegetation.

Members of the genus *Antiporus* are common in still, or relatively still, water in southern Australia. One species, *A. femoralis* Boheman, is particularly common in the South-West. In a recent revision of the genus, Watts (1997) described two additional species from the region, both seemingly rare with one, *A. pembertoni* Watts, known only from one specimen from near Pemberton and the other, *A. hollingsworthi* Watts, from 15 specimens. Since then further collecting has provided two additional localities for *A. hollingsworthi* (30 km N Perth, coll. Watts, 15 km S Northcliffe, coll. Pederzani; both in the South Australian Museum), but none for *A. pembertoni*.

We herein report on and describe two additional species which, like the above, are known from very few specimens. The species were not collected during a recent more intensive survey of wetland invertebrates in the Lake Muir/Poorginup region by A. Storey (personal communication) and will probably prove to have a restricted distribution. The area in which they were found is generally threatened by rising salinity.

We describe the two species here to enable them to be included in the ongoing investigation of this important wetland region.

SYSTEMATICS

Antiporus mcraeae sp. nov.

Type

Holotype: male; 'Melaleuca Swamp, Kodjinup Nature Reserve, 50 km ESE Manjimup, 34°23'45"S 116°39'01"E, W.A. Coll. A. Pinder and J. McRae (CALM), 2/10/98' Registration number WAM 26607, Western Australian Museum.

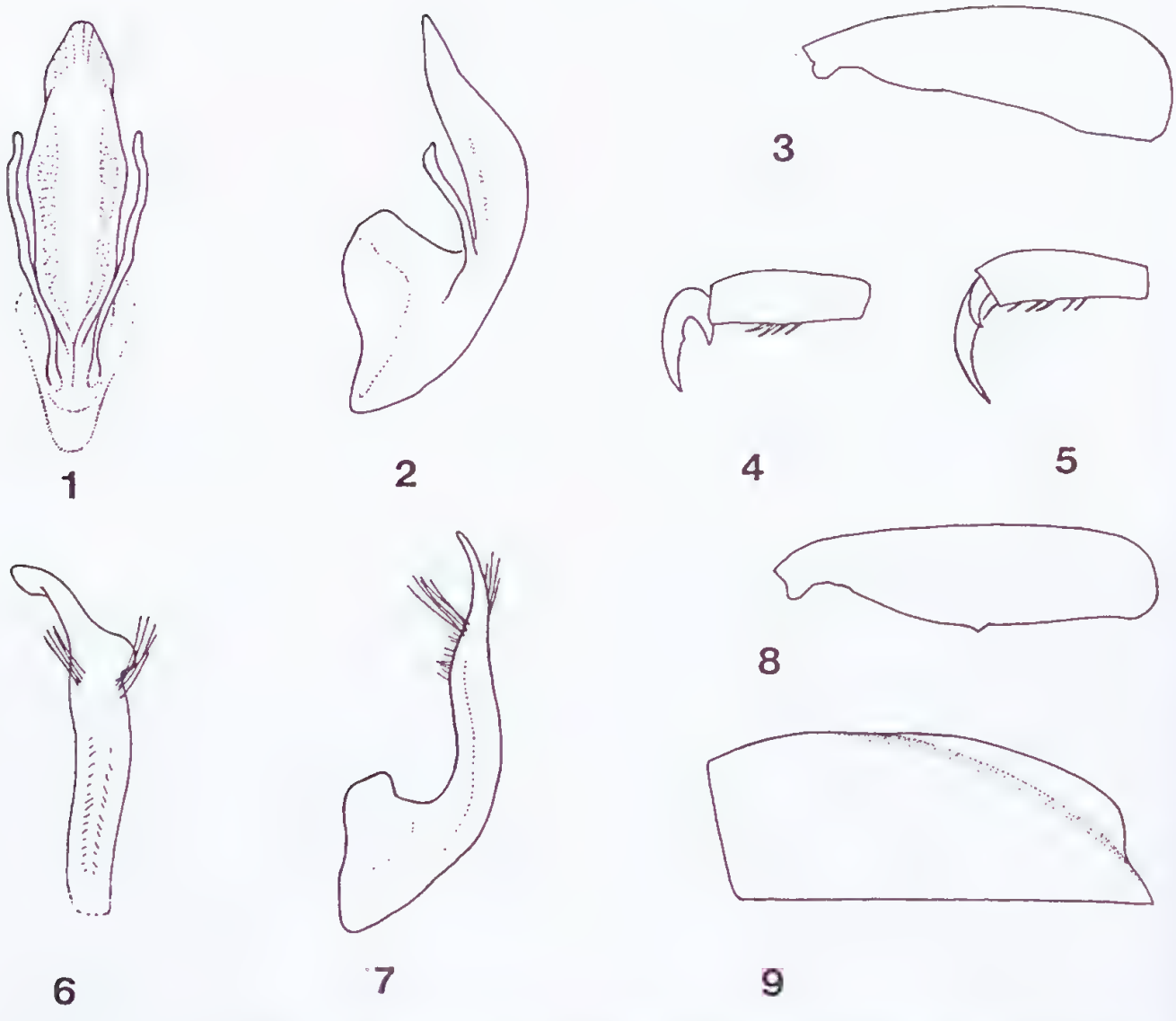
Description (number examined, 1) (Figs 1–4)

Habitus. Length 4.4 mm. Elongate-oval, dark red-brown, sides of pronotum broadly paler, appendages lighter particularly towards extremities.

Dorsal surface. Punctures rather small, regular, those on head smaller than eye facet; row of larger punctures adjacent to suture on elytron; a few small depressions along base of elytron; microreticulation fine, moderately impressed. Pronotal margin narrowly beaded, elytron weakly so.

Ventral surface. Evenly rugose-punctate, punctures somewhat larger than on elytron. Prothoracic process relatively narrow, parallel sided, ridged, tip blunt. Metacoxal lines parallel in posterior quarter, broadening to about 2 times their narrowest width anteriorly, area between them and forward onto mesosternum depressed.

Male. Protarsi moderately expanded, basal segment round, third very deeply bilobed; single claw relatively stout, bent at right angles, with small basal tooth (Fig. 4). Mesotibia quite strongly indented on inner margin near apex; mesotarsi only slightly less expanded than protarsi.



FIGURES 1–9. **1**, Dorsal view of median lobe of aedeagus of *A. mcraeae*; **2**, ditto lateral view; **3**, ventral view of male metafemur of *A. mcraeae*; **4**, lateral view of proclaw and apical tarsal segment of male *A. mcraeae*; **5**, ditto *A. pennifoldae*; **6**, dorsal view of median lobe of aedeagus of *A. pennifoldae*; **7**, ditto lateral view; **8**, ventral view of metafemur of male *A. pennifoldae*; **9**, dorsal view of elytron of female *A. pennifoldae*.

Mesofemur considerably broader towards apex, anterior margin near apex straight (Fig. 3). Median lobe of aedeagus relatively simple but with a thin lateral piece arising from near base on both sides (Fig. 1).

Female. Unknown.

Remarks

The size, colour pattern, relatively broad metacoxal lines with the area between them depressed, male mesotibia indented and male metatibia expanded, place this species in the *A. femoralis* complex. Among these, the relatively weak punctation, the shape of the male metatibia and aedeagus ally it with *A. pembertoni* Watts. It differs from this species in the shape of the male proclaw which is a little more robust and the central lobe of the aedeagus having an additional piece on each side. In this unusual character it resembles *A. pembertoni* which has a single additional piece arising dorsally.

In the key given to Australian *Antiporus* in Watts (1997) it (male) will run to the *A. femoralis* complex. Further identification within this complex depends on characters of the male proclaw, metafemur and aedeagus (see Figs 1–4, and those in Watts (1997).

Habitat

The single specimen was collected from a

small, slightly acidic (pH 6.0), fresh (1.0 ppt) Melaleuca swamp.

Etymology

Named after Jane McRae, the co-collector of the specimen.

Distribution

Known only from the type locality in the wheat-belt region of south-western Western Australia.

Antiporus pennifoldae sp. nov.

Types

Holotype: male; 'Lake Poorginup, 62 km SE Manjimup, 34°32'56"S 116°44'29"E, W.A. Coll. A. Pinder and J. McRae (CALM), 2/10/98'. Registration number WAM 26606. Western Australian Museum.

Paratype: female; same data as holotype, South Australian Museum.

Description (number examined, 2) (Figs 5–9)

Habitus. Length 3.3–3.4mm. Elongate-oval, reddish-brown, appendages lighter.

Dorsal surface. Punctures dense, moderately sized; those on head weaker and sparser, a little smaller than eye facet; a row of large punctures on elytron adjacent to suture, forming weak groove. Pronotum and elytron with narrow but well marked lateral beading. Microreticulation fine, moderately impressed.

Ventral surface. Punctures similar to those on elytron. Pronotal process blunt, sides weakly bowed, moderately ridged. Postcoxal lines parallel in apical quarter, weakly diverging to about 1.4 times narrowest width, area between them flat, not depressed.

Male. Protarsi moderately expanded, proclaw relatively stout, evenly curved with moderate lateral rather than ventral basal spine (Fig. 5). Mesotibia normal, mesotarsi similar to protarsi except that third segment a bit shorter and two claws present. Metafemur a little stouter than in female with a small triangular spine on hind margin in middle (Fig. 8). Apical third of elytron weakly flanged. Median lobe of aedeagus with asymmetric tip in dorsal view, distal portion setiferous (Fig. 6).

Female. Protarsi weakly expanded, two claws. Mesotarsi moderately expanded, more so than protarsi. Metatibia simple. Elytron very widely flanged, beginning in middle and expanding until same width as rest of elytron near apex, then ending abruptly, a short apical portion of elytron not flanged (Fig. 9).

Remarks

A relatively small reddish species, the female of which is instantly recognisable by the strongly flanged elytra. In the male only a rather indistinct narrow flange is present. The distinctly asymmetric and setiferous median lobe of the aedeagus are characters not shared by any other *Antiporus.*

In the key to Australian *Antiporus* in Watts (1997) the females of *A. pennifoldae* can be taken out at the start by the presence of strongly flanged elytra. The males will run to couplet 15, where they can be distinguished from both alternatives by the presence of a small triangular spine on the hind edge in the middle of the otherwise simple metafemur.

The average size, relatively uniform reddish-brown colour and essentially simple metafemora suggest that the species does not belong in the *A. femoralis* complex. It appears to be a rather isolated species.

Habitat

Recorded only from a fresh (0.2 ppt), sedge-filled peat swamp surrounded by Melaleuca shrubs.

Distribution

Known only from the type locality.

Etymology

Named after Melitta Pennifold who was the first to recognise the specific distinction of the specimens.

Acknowledgments

We thank Mr R. Gutteridge for the preparation of the figures, Ms J. McRae for help in the field and Ms M. Pennifold for help in the laboratory.

Reference

WATTS, C. H. S. 1997. Four new species of *Antiporus* Sharp (Coleoptera: Dytiscidae) from Australia, with notes on *A. femoralis* (Boh.) and *A. interrogationis* (Clark). *Records of the South Australian Museum* **30** (1): 35–42.

WHY FLUTES ON BOOMERANGS AND THROWING STICKS?

R. C. NELSON

Nelson, R. C. 2000 Why Flutes on Boomerangs and Throwing Sticks? *Records of the South Australian Museum* 33(1): 21–27.

At first glance it may seem that the longitudinal flutes on the distinctive throwing sticks and hunting boomerangs of Central and Western Australia must diminish their aerodynamic performance. Nothing could be further from the truth. These surface features enhance the performance. Wind tunnel tests show large drag force reductions in the case of throwing sticks and large lift force increases in the case of boomerangs. The fluting alone is responsible for the improved performance. In fact it can be shown that, without the fluting, some boomerangs may not have flown at all.

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Notation

A_n	Projected area onto a plane normal to V.
A_p	Projected area onto a plane parallel to V.
C_d	Drag coefficient (dimensionless).
C_l	Lift coefficient (dimensionless).
D	Diameter.
F_d	Drag force.
F_l	Lift force.
k	Roughness height.
R_e	Reynold's number (dimensionless)
V	Fluid free stream velocity.
ρ	Fluid density.
μ	Fluid dynamic viscosity.

Introduction

The aerodynamics of boomerangs has received considerable attention, particularly those of returning boomerangs. One of the earliest attempts to explain the reason why boomerangs return was that of Wilkinson (1841: see reprint 1973:250–254). This was a totally inadequate explanation. It disregarded the fact that the vanes of the boomerang were airfoils that created lift, and it overlooked the gyroscopic nature of a rotating boomerang and the consequent effects of the precessional moment created by the lift force differential between the two ends of the boomerang. The first rigorous and complete aerodynamic study of boomerangs was that of Walker (1898). His analyses were not limited to returning boomerangs. He was able to explain why boomerangs which had strongly developed convex curvature on both faces (the more curved surface uppermost when thrown) and which also had a small negative twist, produced the required characteristics of a non-returning boomerang if thrown with rotation in a horizontal plane. Returning boomerangs often have positive twist and are thrown with the rotation in a near vertical plane.

The best known study of boomerang aerodynamics is that of Hess (1968). It deals exclusively with returning boomerangs. The main contribution was a theoretical study of the boomerang flight path with comparisons to photographic records of boomerang flights. In a later work, Hess (1975:545–549) did provide a brief theoretical analysis of some characteristics of the non-returning boomerang. Cotteral and Kamminga (1990:175–180) drew heavily on the work of Hess (1968) and did extend their work to a brief consideration of the non-returning boomerang.

No published work is available that relates specifically to the aerodynamics of throwing sticks used in Aboriginal Australia. However, the discussion of maximum and minimum principal axes by Cotteral and Kamminga (1990:179–180) and the flight stability provided by the bend in a boomerang, applies equally well to the flight stability provided by the bend in a throwing stick. The bend prevents spin about the longitudinal axis, eliminating any undesired flight characteristics that might result from phenomena such as the Magnus effect (Roberson and Crowe 1997:446–447).

In recent times, Western fascination for the returning boomerang has been responsible for hi-tech design innovations used in modern sporting

boomerangs but these are not relevant to this study. The above summary does therefore represent the current aerodynamic knowledge applicable to the traditional throwing sticks and boomerangs once used in Aboriginal Australia. What is clear is that while the impact of surface roughness on the performance of these implements has been the subject of some conjecture (e.g. Hess 1975:31, 37), it has never been tested and quantified. Roughness elements can have a profound influence on the characteristics of the boundary layer as air flows over the surface. This in turn determines the pressure distribution around the implement and the size of the wake formed behind the implement. That is, the behaviour of the boundary layer will determine the lift and drag forces on the implement, which in turn directly affect its performance. It is not only a difference between a rough and a smooth surface that is important but the size and type of the roughness is also significant.

On relatively large (dimension parallel to the flow greater than about 1 m if air is the medium), highly streamlined objects, with very gentle surface curvatures, it is necessary to have the surface as smooth as possible to reduce the skin friction drag. However, on relatively small objects (dimension parallel to the flow of less than 100 mm if air is the medium) with relatively tight surface curvatures, significant improvements in the aerodynamic performance can be obtained by the introduction of surface roughness. This results in drag force reduction and lift force increase and is technology used in modern every day life. For example, the dimples on golf balls greatly reduce the drag forces resisting flight, thereby increasing the distance a well hit ball can travel by about 50 percent (Fox and McDonald 1998: 449–451, Young *et al.* 1997: 410–412). Further, the roughness produced by the stitching on a smooth shiny cricket ball, enables a well bowled ball to generate a lift force normal to the flight path and produces what is known as *swing* (Brown and Mehta 1993). This is done by slanting the seam at an angle to the direction of travel so that on one side only does the air pass over the roughness of the stitching to create a turbulent boundary layer.

The reason for these aerodynamic improvements is that the roughness elements initiate transition from a laminar boundary layer to a turbulent boundary layer closer to the leading edge than would occur naturally on a smooth surface. This natural transition would not normally occur within 100 mm of the leading edge of a smooth, streamlined object moving in air at subsonic velocities. If a smooth, streamlined object has a dimension parallel to the flow of less than 100 mm, the boundary layer can only be turbulent if it is initiated by roughness elements. A turbulent boundary layer adheres longer to the surface, into what is an adverse pressure gradient on the rear portion of the object, before the boundary layer separates from the surface. This creates a narrower wake resulting in a smaller drag force. It also reduces the overall pressure force on that surface to below that which would

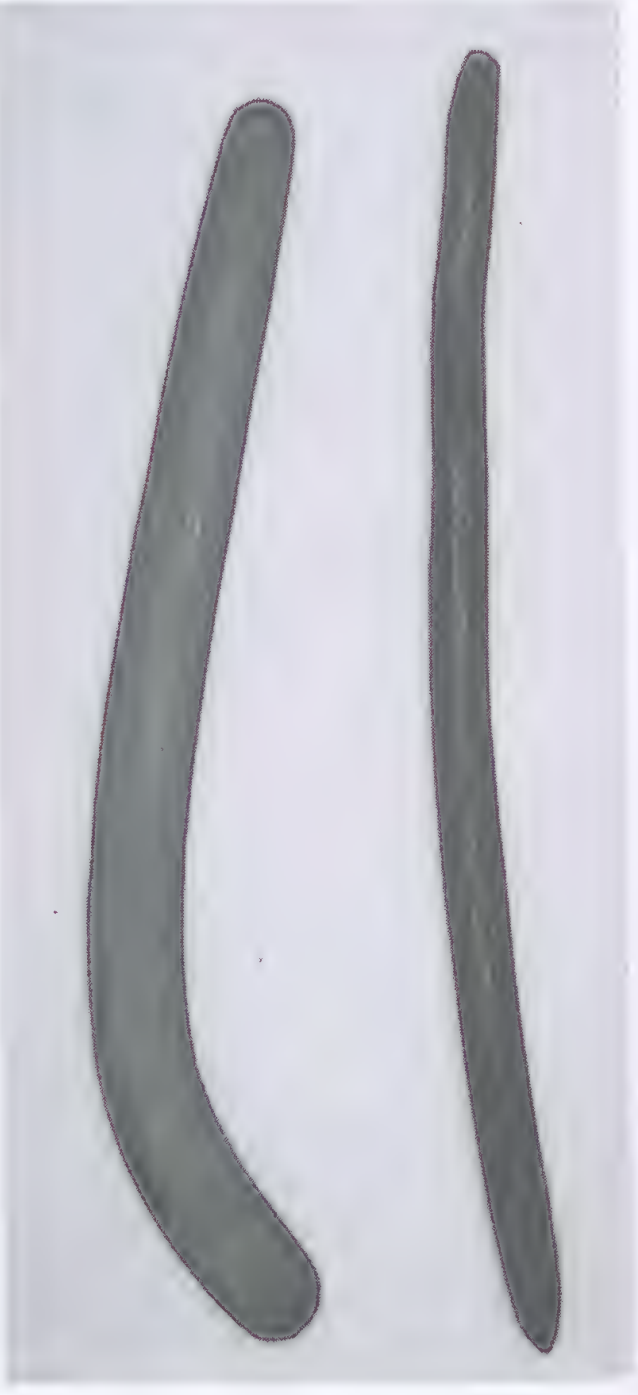

FIGURE 1. Typical specimens of hunting boomerangs and fluted throwing sticks.

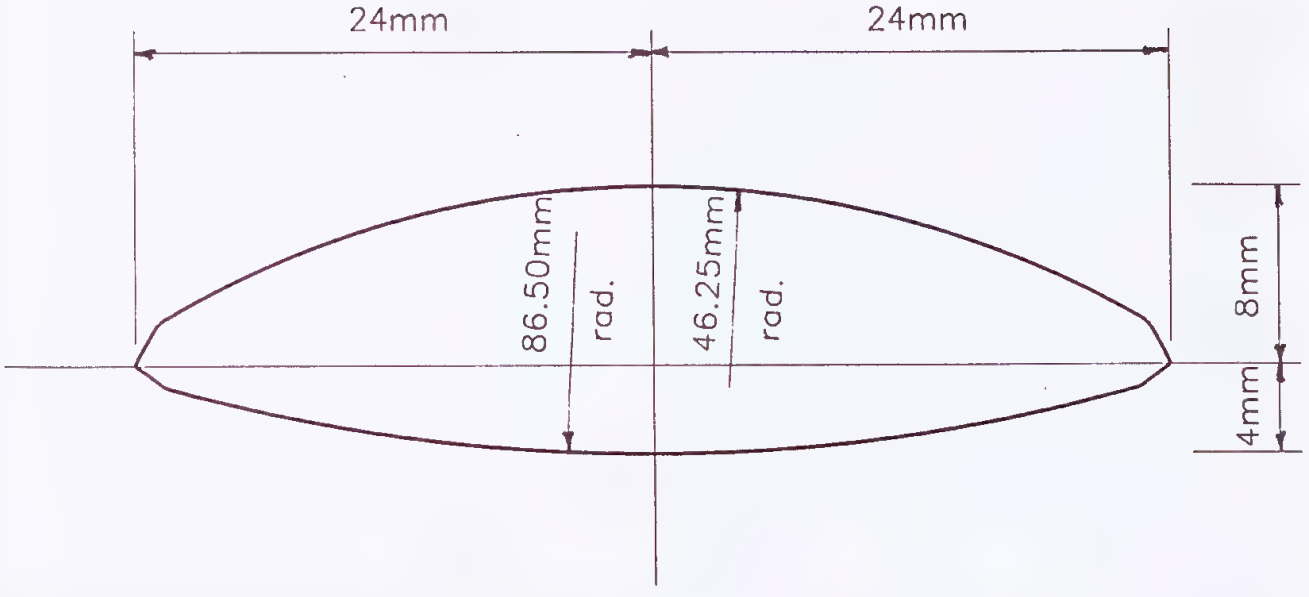

FIGURE 2. Cross-section of smooth foil.

exist if the boundary layer remained laminar. Refer to Street et al. (1996:231–256, 489–418) for further information on boundary layers, drag forces and lift forces.

It is now a small step to suspect that the fluting on the distinctive throwing sticks and hunting boomerangs of Central and Western Australia may have a significant utilitarian purpose. That is, a purpose other than just decorative, ceremonial or sacred in nature, namely aerodynamic. Typical specimens of these artefacts are shown in Fig. 1 while Davidson (1936) has delineated the region where these implements were in use. The specimens shown were collected during the 1920s and belong to the B.L. Hornshaw Collection. Both implements are 640 mm along their axes. The stick has a mass of 521 g (weight 5.11 N), is circular in cross section and has an average diameter of 30 mm. There is longitudinal fluting around the whole circumference. The boomerang has a mass of 314 g (weight 3.08 N) and has a lenticular cross-section that is 48 mm in average width and 12 mm in average maximum thickness. Both faces of the boomerang have a convex curvature, the longitudinal fluting being only on the more highly curved face. In both cases the flutes are about 5 mm wide and 0.2 mm deep. The author perceived that the fluting on the throwing stick was analogous to the dimples on golf balls (drag reduction) while the flutes on the boomerang were analogous to the stitching on a cricket ball (lift enhancement), particularly as the fluting is on one face only.

A series of experiments were designed and undertaken to test these hypotheses. It is these experiments and their results that are the subject of this paper.

Experimental Setup

The experiments were undertaken in a low turbulence wind tunnel with a square test section of side length 457 mm. Wind speeds were measured using a Pitot tube connected to a micro-manometer. The maximum wind speed possible in the tunnel was 37 m/s. Models of the implements were supported in the test section by a balance system capable of measuring both the lift and drag forces exerted on the models. The models were 455 mm long with cross sections modelled at full scale. The models were located at mid height in the tunnel with the longitudinal axis normal to the airflow.

The models were manufactured from aluminium on a computer controlled milling machine to dimensions representative of the actual implements shown in Fig. 1. Both smooth and fluted models were manufactured. The selected diameter of the throwing stick was 30.5 mm. The selected cross section of the boomerang (smooth, without flutes) is shown in Fig. 2. The fluted models were made from smooth models using a 15 mm radius router to manufacture grooves 5 mm wide and 0.214mm deep. Photographs of the fluted models are shown in Fig. 3 and Fig. 4.

FIGURE 3. Fluted cylinder model.

Throwing Stick Experiments

A throwing stick approximates a circular cylinder for which considerable experimentation has already been undertaken, especially for smooth cylinders. Provided the throwing stick is bent, and therefore prevented from spinning about its longitudinal axis, the only aerodynamic force exerted is that of drag. The magnitude of the drag force is given by Eq. 1 where C_d is the dimensionless drag coefficient and A_n is the projected area onto a plane normal to the airflow.

$$F_d = C_d A_n \frac{\rho V^2}{2} \qquad (1)$$

Clearly, the larger the drag coefficient, the larger the drag force at any given velocity. If the value of C_d is known, the drag force on any diameter cylinder, travelling at any velocity in any fluid can be determined from Eq. 1. However, if C_d is not already known it must be determined experimentally. This can be done using one fluid, one cylinder of given D and series of test runs using a range of V. A_n and ρ would be known, V and F_d would be measured and hence C_d derived from Eq. 1.

The value of C_d is also related to R_e, a dimensionless number defined in Eq. 2 that can also be evaluated from the experimental procedures described above.

$$R_e = \frac{\rho V D}{\mu} \qquad (2)$$

The function of C_d versus R_e for a smooth circular cylinder is given in Fig. 5 after Schlichting (1968). The near horizontal portion of the curve at C_d values of about 1.2 is the region where the boundary layer is laminar. At R_e values between $2\text{x}10^5$ and $4\text{x}10^5$ the boundary layer goes through transition from a laminar to a turbulent boundary layer until at R_e values greater than about $4.5\text{x}10^5$, the boundary layer is completely turbulent and a very significant reduction in C_d is observed. The advantage of having a turbulent boundary layer is obvious. Unfortunately, this could never be achieved on a 30.5 mm diameter, smooth throwing stick, as it would require airflow velocities in excess of about 200 m/s (720 km/hr). The highest value of R_e possible in the wind tunnel was $7\text{x}10^4$ for a stick diameter of 30.5 mm.

Achenbach (1971) showed how roughness modified the function of C_d versus R_e. The results, shown as the dotted lines in Fig. 5, indicate that the introduction of surface roughness induces transition to a turbulent boundary layer at much lower values of R_e than would occur for a smooth cylinder of the same diameter. The k/D values are the relative roughnesses of the cylinders tested, larger values representing rougher surfaces in relative terms, the roughness type used being sand grains. For example, $k/D = 0.0090$ is equivalent to

FIGURE 4. Fluted foil model.

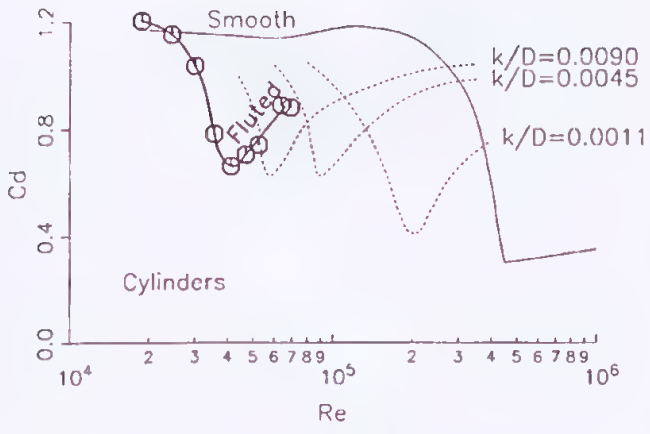

FIGURE 5. *Cd* versus *Re* functions for cylinders.

a sand grain roughness diameter of 0.27 mm on a 30.5 mm diameter cylinder.

The results for the 30.5 mm diameter fluted cylinder are shown in Fig. 5 as the heavy solid line and indicate that the fluted roughness is equivalent to something greater than a sand grain roughness of 0.27 mm. The minimum drag coefficient occurs at R_e equal to 4×10^4, one order smaller than that for a smooth cylinder.

The dimensionless functions shown in Fig. 5 are universally applicable to any cylinders in any fluid. The impact of flutes on a specific aboriginal throwing stick is best illustrated in Fig. 6 where, for any given velocity less than 37 m/s, the ratio

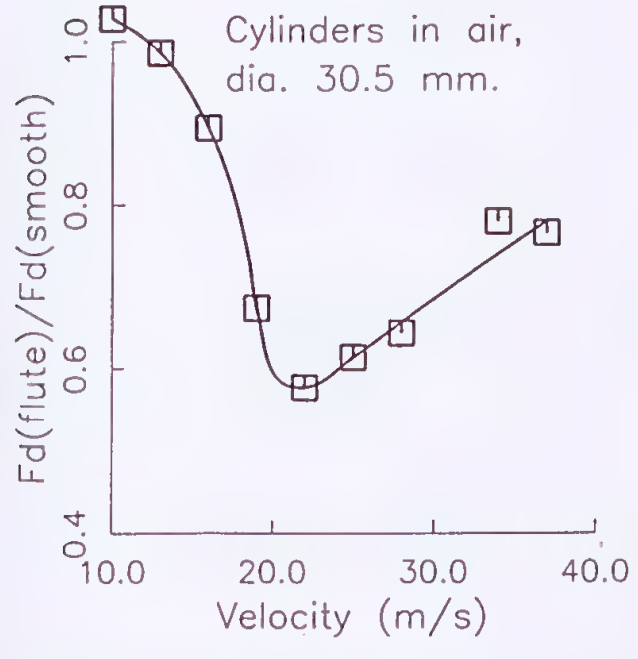

FIGURE 6. Drag force ratios – fluted cylinder/smooth cylinder.

of the drag force on a fluted stick to that on a smooth stick of the same length and diameter, is given. Drag force reductions of up to 40 percent are achieved at velocities of between 20 m/s and 30 m/s with reductions of 20 percent at velocities of 40 m/s. These velocities are achievable by throwing. The velocity of translation of a thrown stick on leaving the hand was probably between 20 m/s and 30 m/s with a superimposed rotation of about 5 rps (revolutions per second) adding a further 10 m/s at the extremity of the forward moving arm. The flutes appear to be the exact type of roughness required to obtain maximum drag force reduction on aboriginal throwing sticks.

Boomerang Experiments

The lenticular cross section of a boomerang, with one surface more highly curved than the other, enables the arms to behave as rudimentary airfoils that will generate a lift force in a direction normal to the direction of the air stream. Drag forces are also generated but, due to the more streamlined nature of the cross section, they are very much smaller than those generated by the throwing stick. They are of secondary importance to the lift forces in the context being considered here. The lift force counteracts the gravity force and prolongs the distance over which the boomerang can be propelled. It is this ability to generate lift that distinguishes a boomerang from a throwing stick.

The magnitude of the lift force is given by Eq. 3, which in form is very similar to the equation

$$F_l = C_l A_p \frac{\rho V^2}{2} \qquad (3)$$

for drag force (Eq. 1) but with different definitions of some terms. C_l is the dimensionless lift coefficient and A_p is the projected area of the airfoil onto a plane parallel to the airstream direction.

Clearly, the larger the lift coefficient the larger the lift force at any given velocity. However, as with the cylinder, if the lift coefficient is unknown it must be determined experimentally. With A_p and ρ known and V and F_l measured, the value of C_l can be derived.

The value of C_l varies with the angle of attack, the angle between the chord of the airfoil and the direction of the airstream. The results for the airfoils tested are given in Fig. 7 and show the lift coefficient to be much larger for the fluted foil

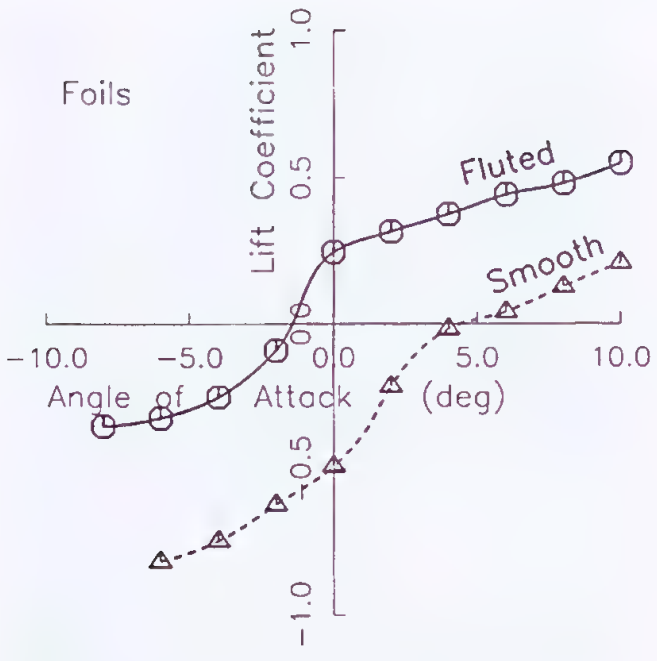

FIGURE 7. Lift coefficient versus angle of attack for foil models.

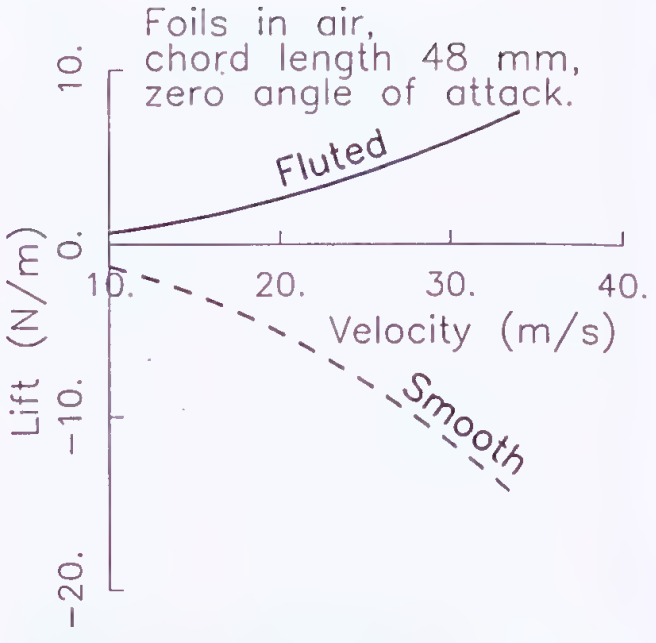

FIGURE 8. Lift forces on foil models.

than for the smooth foil at all angles of attack tested. The smooth foil did not generate positive lift (upward lift) until the angle of attack exceeded about +5 degrees. The angle of attack for most of the length of a hunting boomerang is zero degrees. A small negative twist (negative angle of attack) is sometimes placed on the outer tip to lessen the lift force in that region to reduce the precessional moment that might otherwise cause the boomerang to climb excessively (Walker 1898 and Cotteral and Kamminga 1990:180).

In the absence of flutes, the boomerang modelled would not have flown at all as evidenced by the very significant negative lift coefficient (-0.5) at zero angle of attack. Flow visualisation techniques indicated that on the more gently curved underside, flow separation was delayed until very near the trailing edge, while flow separation occurred early on the rear half of the more highly curved topside. The result was an efficient negative (downward) force on the underside but a lesser, inefficient, positive (upward) force on the topside, the sum total being a negative (downward) lift force.

The flow separation on the topside of the fluted foil was delayed until very near the trailing edge, thereby generating an efficient, positive (upward) force that exceeded the magnitude of the negative (downward) force on the smooth underside, the sum total being a net positive (upward) lift force. The flutes induce a turbulent boundary layer that can adhere longer to the more tightly curved surface, as described in the Introduction. It should be noted that roughness on the underside would have little impact on the lift characteristics. The airflow was able to adhere satisfactorily to the more gently curved, smooth surface without the assistance of roughness. Therefore, the fact that a boomerang may have some roughness on the underside (adze marks for example) is not important.

Fig. 8 shows the overall lift forces generated on the two models, while Fig. 9 shows the increase in lift force generated by the presence of flutes. The values are given in Newtons per metre length

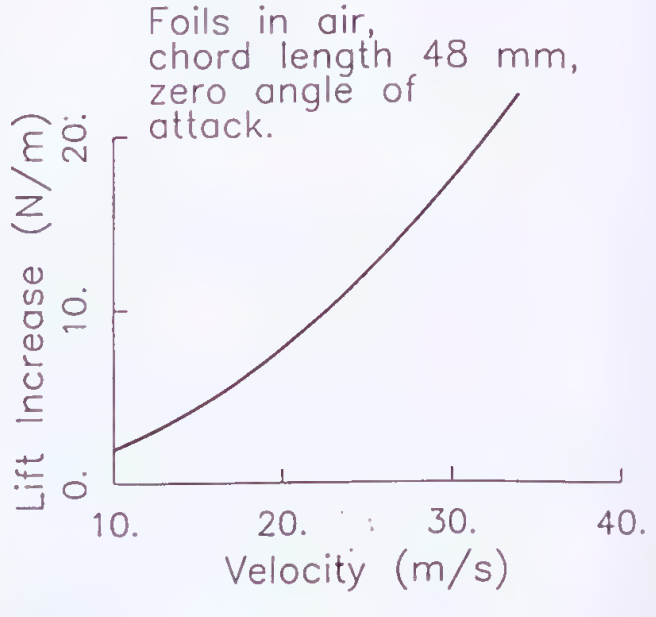

FIGURE 9. Increase in lift force attributable to flutes.

of foil (N/m). A hunting boomerang typically weighs between 4.5 N/m and 5.0 N/m. Therefore, the fluted foil tested has the lift characteristics required of a boomerang launched at a velocity of translation of between 20 m/s and 30 m/s and a rotation of about 5 rps, values thought to be characteristic of those actually used in Aboriginal Australia (refer to section Throwing Stick Experiments).

Comments and Conclusions

The testing of fluted and non-fluted samples of throwing sticks and boomerangs has shown that their aerodynamic performance is notably improved by the fluting. The wind tunnel tests show large drag force reductions for throwing sticks and considerably increased lift forces for boomerangs. The fluting alone is responsible for this improved performance. The fluted boomerang tested appears to have the optimum lift characteristics. Without the fluting it has negative net lift and therefore, becomes less efficient than a throwing stick which has zero net lift. The flutes on the throwing stick seem to be the optimum roughness to maximise drag reduction benefits.

The use of roughness elements in pre-European Australia (flutes in this case) appears to be consistent with their use in contemporary times as a technology for enhancing aerodynamic performance. Fact must, however, be separated from conjecture. It is fact that the fluting improved the performance of these artefacts as hunting tools and fighting weapons. As to whether there was an empirical process that resulted in a conscious decision to keep the flutes for this purpose is in the realm of conjecture, because the same flutes are on items that had no aerodynamic requirements, such as wooden bowls. However, there is the possibility that, along with many early inventions, the fluting was a serendipitous discovery implemented for advantage.

If the fluting on a boomerang created too much lift near the outer tip, a larger than desired precessional moment would be generated and the boomerang would climb excessively. This can be remedied by omitting the fluting near the tips. Perhaps this accounts for those boomerangs similar in all respects to that shown in Fig. 1, but with fluting only over about the middle one third of the longitudinal length. The precessional moment can also be reduced by the negative twist often present on hunting boomerangs.

References

ACHENBACH, E. 1971. Influence of surface roughness on the cross-flow around a cylinder. *Journal of Fluid Mechanics* **46**(2): 321–355.

BROWN, B. & MEHTA, R. 1993. 'The Seamy Side of Swing Bowling.' *New Scientist*, **139**(1887): 21–24.

COTTERAL, C. & KAMMINGA, J. 1990. 'Mechanics of Pre-Industrial Technology.' Cambridge: Cambridge University Press.

DAVIDSON, D. S. 1936. Australian throwing sticks, throwing clubs, and boomerangs. *American Anthropologist, New Series* **38**(1): 76–100.

FOX, R. W. & McDONALD, A. T. 1998. 'Introduction to Fluid Mechanics.' 5th ed. New York: John Wiley & Sons, Inc.

HESS, F. 1968. The aerodynamics of boomerangs. *Scientific American* **219**(5): 124–136.

HESS, F. 1975. 'Boomerangs, Aerodynamics and Motion.' Doctoral Thesis, Rijksuniversiteit Te Groningen.

ROBERSON, J. A. & CROWE, C. T. 1997. 'Engineering Fluid Mechanics.' 6th ed. New York: John Wiley & Sons, Inc.

SCHLICHTING, H. 1968. 'Boundary Layer Theory.' 6th ed. New York: McGraw Hill.

STREET, R. L., WATTERS, G. Z. & VENNARD, J. K. 1996. 'Elementary Fluid Mechanics.' 7th ed. New York: John Wiley & Sons, Inc.

WALKER, G. T. 1898. On boomerangs. *Philosophical Transactions Royal Society London, Series A* **190**: 23–41.

WILKINSON, H. 1841. 'Engines of War.' London: Longman, Orme, Brown, Green, and Longmans. Reprinted in Richmond by Richmond Publishing Co. Ltd., 1973, with new introduction by W. S. Curtis.

YOUNG, D. F., MUNSON, B. R. & OKIISHI, T. H. 1997. 'A Brief Introduction to Fluid Mechanics.' New York: John Wiley & Sons, Inc.

REVISION OF AUSTRALIAN *CHAETARTHRIA* STEPHENS (COLEOPTERA: HYDROPHILIDAE)

C. H. S. WATTS

WATTS, C. H. S. 2000. Revision of Australian *Chaetarthria* Stephens (Coleoptera: Hydrophilidae). *Records of the South Australian Museum* **33**(1): 29–31.

The genus *Chaetarthria* in Australia is revised. The synonymising of *Chaetarthria australis* Knisch and *C. sjostedti* Knisch with *C. nigerrima* (Blackburn) by Balfour-Browne is confirmed. This species is the only one present in Australia. It is patchily distributed in coastal northern and eastern Australia.

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The hydrophilid genus *Chaetarthria* Stephens, 1835 contains numerous species, predominantly in the Neotropical and Neartic regions (Hansen 1991). The extensive New World fauna has been reviewed by Miller (1974) and Spangler (1977). In comparison the Australian fauna is depauperate with only one recognised species, *C. nigerrima* (Blackburn, 1891), although two others, *C. sjostedti* Knisch, 1922a and *C. australis* Knisch, 1922b, have been described. None are described from nearby Indonesia or New Guinea but I would expect the genus if not the species to also occur there. Apart from the original descriptions nothing has been written on the Australian species.

The genus belongs in the tribe Chaetarthriini, readily recognised by their globular shape and either divided eyes or the first and second ventrites having a large cavity normally filled with a hyaline mass and covered by long setae arising from the front edge of the first ventrite (Hansen 1991). The tribe is represented in Australia by two genera: *Amphiops* and *Chaetarthria*. From *Amphiops, Chaetarthria* can readily be separated by their undivided eyes, small size (< 2.0 mm.) and, in the Australian species at least, virtual lack of punctures.

The collections from which specimens were examined are listed under the following abbreviations:

ANIC Australian National Insect Collection, CSIRO, Canberra
BMNH Natural History Museum, London
MV Museum of Victoria, Melbourne
NTM Northern Territory Museum, Darwin
NRS Naturhistoriska Riksmuseet, Stockholm
SAMA South Australian Museum, Adelaide
DPIM Queensland Department of Primary Industries, Mareeba.
UQIC University of Queensland Insect Collection, Brisbane

Systematics

Genus *Chaetarthria* Stephens, 1835

Chaetarthria nigerrima (Blackburn,1891)

Paracymus nigerrimus Blackburn, 1891.

Chaetarthria nigerrima (Blackburn, 1891); J. Balfour-Browne, 1938; Gentili, 1993.

Chaetarthria australis Knisch, 1922b; J. Balfour-Browne, 1938.

Chaetarthria sjostedti Knisch, 1922b; J. Balfour-Browne, 1938.

Types

Paracymus nigerrimus Blackburn. *Lectotype*: 'Australia Blackburn Coll. B.M. 1910-236' 'Paracymus nigerrimus, Blackb' 'T 3566' BMNH. Blackburn gave the locality as 'Mountains of Victoria' in his original paper. Herein designated.

Chaetarthria sjostedti Knisch. *Lectotype*: 'Malanda' 'Queensl. *Mjoberg*' 'Type' 'Chaetarthria Sjostedti m. Nsp. A.Knisch 1921' '5348 E91 +' with red TYPUS label, NRS. Herein designated.

Paralectotypes: 1, 'Ma-landa' 'Queensl. *Mjoberg*' '5347 E91+, (missing head and thorax), NRS. 1, '3566' 'Victorian Alps Blackburn' 'Paracymus nigerrimus, Blackb. Co-type', SAMA. Herein designated.

Chaetarthria australis Knisch. Syntypes: Not located. Type locality given as Gayndah, Queensland. Knisch 1922b gives the locations of the types as Museum Godeffroy No 10696 and 10701 and a further example in the Hamburg Museum.

Description (number examined, 296) Fig. 1

Length 1.5–2.5mm. Round, deep bodied, height of elytra a bit less than half length; dorsal surface shiny black, sides of pronotum, edges of elytra and apex of elytra light testaceous-yellow, ventral surface dark-testaceous, appendages a little lighter.

Dorsal surface: Head relatively narrow, sides converging somewhat in front of eyes, finely reticulate, very weakly punctate; labrum large, front edge straight or very weakly concave, with moderate punctures stronger than on rest of head. Pronotum smooth apart from weak fine microreticulation and sparse weak punctures at sides and along front margin, disc virtually impunctate. Elytron shiny, microreticulation weak, about twenty rows of serial punctures (these are very weak and hard to trace other than from the ventral surface with transmitted light), sutural groove strong in apical half, then progressively weaker forwards but still traceable almost to scutellum.

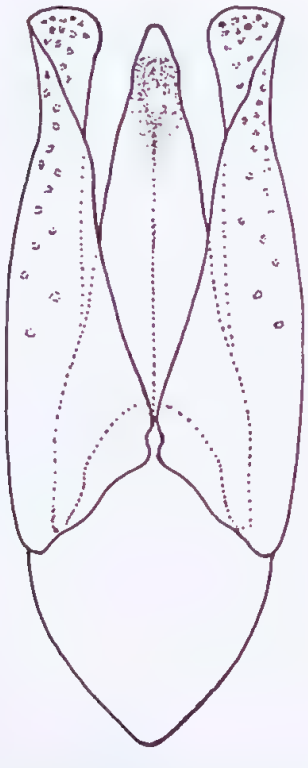

FIGURE 1. Dorsal view of aedeagus of *Chaetarthria nigerrima* (Blackburn) from Millstream, W.A.

Ventral surface: Shiny, microreticulation weak; metasternum with quite strong setae in middle; first ventrite with confluent row of very long, strong, golden setae along front edge reaching to third ventrite, a similar row of much shorter setae on rear edge of second ventrite pointing backwards, short inward-pointing setae at sides of second ventrite; other ventrites with quite dense covering of short setae/spines except for front half of third ventrite; epipleuron broad in front, rapidly narrowing to middle, absent behind, almost in same plane as sides of elytron.

Appendages: Maxillary palpi relatively short, apical segment about 2.5 times length of penultimate, with 3–5 small, elongate sensillae on the outside at base. Protibia relatively narrow, parallel-sided for most of length, with numerous blunt spines towards apex but without modified setae; procoxa with around eight strong spines on ventral surface near base. Ventral surface of pro- and mesofemora covered with short golden setae except close to base, metafemur without such setae except along front edge.

Male: Basal piece of aedeagus short, paramere tips flared, truncated, apical portions and inner edges semi-membranous and less chitinised than rest of paramere (Fig.1).

Remarks

Chaetarthria nigerrima has a wide distribution around northern Australia from the Pilbara region of Western Australia to eastern Victoria. It is not common but when present is often abundant in a small area. I suspect that the species might be semi-colonial. One such aggregation that I found in the Northern Territory was living in small tunnels in wet sand just above, and possible also below, the waterline at the edge of a sandy pool in a drying river bed. Other specimens are recorded as having been collected among gravel at the water's edge. It also comes to light which is how most of the specimens were collected. Miller (1974) likewise recorded the genus in North America as predominantly living in sand and gravel at the edge of still or relatively still water, and also flying to light. The larva of *C. nigerrima* is unknown but that of the European *C. seminulum* Herbst, 1797 has been described by Böving and Henriksen (1938).

Knisch, who was unaware of Blackburn's species, described two additional species, one from Gayndah, Queensland and the other from Malanda, Queensland. The type of *P. nigerrimus* Blackburn and the type of *C. sjostedti* belong to the same species. The types of *C. australis* would

appear to have been lost but there is nothing in the description that would clearly distinguish it from *C. nigerrima* and this and the fact that all modern specimens appear to belong to the one species lead me to agree with Balfour-Browne (1938) that *C. australis* Knisch, 1922b is a junior synonym of both *C. nigerrima* (Blackburn) and *C. sjostedti* Knisch, 1922a.

Note on priority: The description of *C. sjostedti* was published on the 24th of January 1922 (Knisch 1922a), not in 1921 as given in Knisch 1924. In June the same year Knisch published the description of *C. australis* and at the same time also reprinted his earlier description of *C. sjostedti* (Knisch 1922b) as a new species.

Distribution

Australian Capital Territory: Bendora Dam, ANIC; Black Mountain, ANIC. **New South Wales:** 17 km SE Braidwood, ANIC; Cabbage Tree Creek, Canberra-coast road, ANIC; Chichester State Forrest, ANIC; Valery, ANIC. **Northern Territory:** Bessie Springs, ANIC; Nourlangie Creek, 20 km SSW Jabiru, SAMA; 19 km E by S Mt Borradaile, ANIC; Muirella Park, Kakadu National Park, DPIM; U. D. P. Falls, Kakadu National Park, NTM; Upper South Alligator River, ANIC. **Queensland:** Bushland Beach, 20 km N Townsville, SAMA; Bushy Creek, Mossman-Mt Lewis road, ANIC; Cairns District, SAMA; 25 km N Cooktown, ANIC; 30 m N Cooktown, UQIC; 70 km SW Greenvale, SAMA; Henrietta Creek, Palmerston National Park, UQIC; Iron Range, DPIM; Kennedy Creek S of Laura, DPIM; 25 km N Laura, DPIM; Kuranda, ANIC; 30 km W Laura, DPIM; 22 km S Mareeba, DPIM; Millaa Millaa Falls, UQIC; Mossman-Mt Lewis road near Julatten, ANIC; Mt Surprise, DPIM; 22 km N Mt Molloy, ANIC; North Pine River, UQIC ; Palmerston National Park, UQIC; 15 km NNW South Johnstone, DPIM; 20 km S Townsville, SAMA; Stewart Range, SAMA; Walkamin, DPIM; Windsor Tableland, DPIM. **Victoria:** Genoa, ANIC; Meredith, MV; Victorian Mountains, BMNH. **Western Australia:** Fitzroy River, ANIC; Millstream, ANIC; 1 km N Millstream, ANIC; Wittenoom Gorge, ANIC.

Acknowledgments

I would like to thank the curators of the collections listed earlier for allowing me ready access to specimens in their care. Ms D. Churches put the final touches to the manuscript, Mr R. Gutteridge prepared the figure and the librarians, Mrs M. Anthony and Mrs J. Evans, helped with the library references particularly the dating of Knisch's two publications.

References

BALFOUR-BROWNE, J. 1938. A contribution to the study of the Palpicornia.1. *The Entomologist's Monthly Magazine* **74**: 102–107.

BLACKBURN, T. 1891. Further notes on Australian Coleoptera, with descriptions of new genera and species. *Transactions of the Royal Society of South Australia* **14**: 65–153.

BÖVING, A. G. & HENRIKSEN, K. L. 1938. The developmental stages of the Danish Hydrophilidae. *Videnskabelige Meddelelser fra den Dansk Naturhistoriske Forening i Kjøbenhavn* **102**: 27–162.

GENTILI, E. 1993. *Paranacaena* Blackburn, 1889: a valid genus (Coleoptera, Hydrophilidae). *Giornale Italiano di Entomologia* **6**: 285–296.

HANSEN, M. 1991. The Hydrophiloid Beetles. Phylogeny, Classification and a Revision of the Genera (Coleoptera, Hydrophiloidea). *Biologiske Skrifter* **40**: 1–368.

KNISCH, A. 1922a. Results of Dr E. Mjöberg's Swedish Scientific Expeditions to Australia 1910–1913. 29. Hydrophilidae. *Arkiv för Zoologi* **14**, number 17: 4pp.

KNISCH, A. 1922b. Hydrophiliden-Studien (Op. 10.) *Archiv für Naturgeschichte* **88**: 87–126.

KNISCH, A. 1924. Hydrophilidae, *in* 'Coleopterorum Catalogus pars 79'. Eds. Junk and Schenkling. Berlin, 306pp.

MILLER, D. R. 1974. Revision of the New World *Chaetarthria* (Coleoptera: Hydrophilidae). *Entomologica Americana* **49**:1–123.

SPANGLER, P. J. 1977. Three new Ecuadorian species of the aquatic beetle genus *Chaetarthria* (Coleoptera: Hydrophilidae). *Proceedings of the Biological Society of Washington* **90**: 566–578.

WORDS TO OBJECTS: ORIGINS OF ETHNOGRAPHY IN COLONIAL SOUTH AUSTRALIA.

PHILIP G. JONES

JONES, P. G. 2000. Words to objects: origins of ethnography in colonial South Australia. Records of the South Australian Museum 33(1): 33–47.

During the two decades preceding the establishment of the South Australian Museum in 1856, colonial ethnography was an ill-defined project, influenced by the diverse aims of social philanthropists, Christian missionaries and those intent upon creating optimum conditions for the colony's economic growth. This paper notes the significant role of individual ethnographers such as Eyre, Grey, Angas and Cawthorne in producing descriptive ethnographies and in collecting associated series of artefacts for a British, rather than a local Australian public. This factor slowed any impetus towards a local ethnographically-oriented museum. The paper documents another factor; the efflorescence in philological studies of South Australian languages during the 1830s and 1840s, which overshadowed local interest in assembling museum collections of ethnographic material.

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Philanthropists And Fringe Dwellers

Meeting in London during 1834, the South Australian Literary and Scientific Association had shown an interest in Australian Aborigines even before the new colony was proclaimed. Expressed in lectures on the phrenological and physiological character of the Aborigines, or their treatment at the hands of British colonists, this interest had less to do with ethnographic theory than with colonialist practice. Phrenological technique was perceived as a means, not only of discovering more about a strange people for the sake of science, but also of managing these encounters more efficiently and, if possible, more humanely than on the colonial frontiers of New South Wales or Tasmania (Reece 1974: 85–93). South Australia's Adelphi planners were aware that their treatment of the Aborigines would test their stated humanitarian objectives for the new colony.

South Australia's first Chief Justice stated the case in these terms: 'The system hitherto adopted in the immediate neighbourhood of this Province, towards the native population, is one at which humanity shudders ... But such is not the system which will be adopted towards them here, where I trust, under Providence, that a new era is about to dawn for them'.[1] Interestingly, this opinion was expressed in an 1837 court case in which two white men had been charged with the theft of a jacket and some 'warlike implements (spears and waddies) from some of the aboriginal inhabitants of this Province'—one of the first documented cases of direct appropriation of Aboriginal artefacts in South Australia.[2] This optimism prevailed at least until 1839 when the *Southern Australian* expressed the view that '[f]or the first time in the history of colonisation, the civilised and uncivilised man have met without collision, and emigration has brought with it a blessing rather than a curse'.[3]

By 1841, following the massacre of the 'Maria' shipwreck survivors and the Rufus River affray, attitudes of South Australian colonists towards Aborigines had noticeably hardened (Pope 1989). Controversy surrounding the legality of the *ex judice* executions of two Coorong Aboriginal men for their part in the 'Maria' massacre helped to crystallise the new status of South Australian Aborigines as British subjects (ibid 144–45). With the privileges attached to this legal standing, such as the capacity to serve as witnesses in criminal

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[1] Sir John Jeffcott, address to Grand Jury, quoted in the *Register*, 3 June, 1837, p.5.

[2] *Ibid:* 4–5. The offence was committed in an Aboriginal hut at Glenelg.

[3] Editorial comment, *Southern Australian*, 16 June, 1838, p.4.

trials, came an entanglement of legal regulation directed at defining and circumscribing Aboriginal autonomy and movement in the Adelaide region. As Colonel Light's grid of streets and squares took shape, so Aboriginal hunting and gathering practices near settled areas became increasingly problematic. Aborigines were drawn into the local European economy and their previously unfettered range was restricted to defined living areas such as the 'Native Location' or semi-permanent camps such as those at Glenelg or at Kensington.[4]

During 1847 a plan was drawn up to create restricted areas within the city's parklands for the Aborigines and their 'wurlies'.[5] Aboriginal children were encouraged or coerced into the missionaries' day school, while their parents were engaged as hewers of wood and fetchers of water. As early as 1839 Robert Gouger had observed that 'a little sugar, biscuit, or bread is sufficient inducement for them to bring wood, water or stone for building, and several instances have occurred of ten or twelve of these poor fellows working during six hours consecutively for an individual for biscuit [sic]'.[6] During 1840 the *Adelaide Chronicle* published an article discussing a 'scheme for the indoctrination of industrious habits amongst the Aborigines'.[7] Three years later, 'the best means of civilising Aborigines' was discussed at one of the early meetings of the Adelaide Literary and Scientific Association and Mechanics Institute, the precursor of the colony's Library and Museum.[8]

Aborigines in colonial Adelaide had been effectively marginalised by the later 1840s. The frontier, and the danger which it represented to the young and vulnerable capital, had receded beyond everyday sight and discussion. This period saw the image of the ignoble mendicant and the 'comic savage' displace that of the noble savage encountered by South Australia's First Fleet. Edward Snell's first impression of Adelaide Aborigines in 1850 reveals this shift: 'Plenty of natives stalking about the streets half naked—most of the women with nothing on but a blanket and nearly all of them the ugliest wretches it is possible to conceive' (Snell 1988: 49).

The progression in European depictions of the Aborigine observed by Bernard Smith for Sydney's first two decades is also evident in Adelaide (Smith 1984: 174–75, 220–21). With the increasing tendency to reduce Aborigines to stereotypes in commentary, journalism and art, came an inclination to apply more general policies which took even less account of specific Aboriginal requirements. Of course this trend was not universal; the exotic character of Aboriginal life remained an important ingredient of colonial Adelaide for at least a decade after settlement. Images of the noble savage continued to surface—at the *palti* or *kuri* dances held at full moon, or on the battlefield during periodic confontations between the Adelaide, Encounter Bay, and River Murray groups. Even these occasions were subject to European surveillance or control; the corroborees were usually attended by European voyeurs (invited or not), while the battles were often either terminated or forestalled altogether by police intervention.[9] One of William Cawthorne's most telling watercolour depictions of the Aboriginal subject at this time was his study of a pile of decorated shields and spears, smashed by police horses to prevent tribal fighting near Adelaide.[10] Cawthorne was sufficiently disturbed by this event to write an article for the *Register*, on behalf of one of the principal Adelaide elders, King John (Mullawirraburka):

> On Monday last, a fight was to have taken place between Moorundee, Encounter Bay, and Adelaide natives. Great preparations are accordingly made. The young men were all in high glee—tattooed [printed in error for 'karkooed', ochred], oiled, and all ready for the coming amusement, but unfortunately they were disappointed; for, as they were marching to meet each other on the old Bay

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[4] See Foster 1991. For example, in June 1837 the Protector of Aborigines noted that he had removed 'certain Aborigines who had settled on Dr Wright's town acre' and a few weeks later John Morphett complained that Aborigines were cutting down trees on his town acre (GRG 24/1/1837/210; 246). In December 1838, the Superintendent of Police reported the 'habit of the Aborigines of disfiguring trees in the Park Lands, yet during the same year colonists were employing Aborigines to remove timber from the same areas (GRG 24/4/1838/20; 24/1/1838/8, SRO). For a broader discussion of this issue, see Reynolds (1990: 129–163).

[5] GRG 24/61847/440, State Records, South Australia

[6] Gouger 1838: 56. By 1847 Adelaide Aborigines were being employed to break stones for paving the city's streets (GRG 19 24/4/1847/273, State Records, South Australia).

[7] *Adelaide Chronicle*, 18 & 25 February, 1840, p.3; p.2.

[8] The meeting canvassed a range of strategies, ranging from the establishment of a native police force to the dual operation of a 'House of Correction' and a 'Native Location'. See the *Southern Australian* 28 February, 1843, p.2; *Adelaide Examiner* 25 February, 1843, pp.3–4.

[9] See Angas (1847a, vol.1: 102–108) and Leigh (1839: 143) for descriptions of corroborees attended by Europeans at this time.

[10] Cawthorne Diary, Monday, 22 April, 1844, Foster (ed.) 1991: 46. The original drawing is contained in the Cawthorne mss., Mitchell Library, Sydney

> road, three horse-police very unceremoniously stopped them, and had every spear and shield laid on the ground, and broken up. The astonishment that this act produced, was truly remarkable—some looked quite aghast, others were confounded, and many for the moment, I dare say, doubted their senses, whether such a collection of beautiful uwindas and shields, kylahs and midlays, were absolutely to be destroyed.[11]

By the later 1840s these events, and Aborigines themselves, had become no more than a picturesque backdrop to the bustling activity of colonial Adelaide. Already in 1843 Aborigines were tried for 'appearing naked' in Gawler Place. 'Sunday corroborees' were finally forbidden during 1847.[12] The careful, individual portraiture of George French Angas and William Cawthorne was gradually supplanted by the caricatures and drawings of S. T. Gill, Alexander Schramm, and Edward Snell, or by landscape painting in which 'the aborigine [was] relegated increasingly to fulfil the function of a pictorial embellishment to topographic landscape, providing a local touch and pointing the contrast between primeval life and the busy progress of the town'.[13]

During the years following European settlement the curiosity value of Aboriginal objects, like their owners, steadily diminished. Familiarity bred contempt. Some collections of Adelaide Plains artefacts continued to make their way to Europe, evoking, like trophy displays, the raw experience of the colonial frontier, but little attention was paid to the preservation or classification of such artefacts in Adelaide itself during the 1840s or 1850s. A factor of some significance, particularly in the light of the marked effect on local collecting practice triggered by the demand for Aboriginal artefacts for the International Exhibitions of the 1870s, may lie in the British Museum's focus (and that of British collectors) on the Assyrian antiquities, first acquired in 1849 (Bohrer 1994). The British Museum's preoccupaton with antiquities during the late 1840s and 1850s may well have been mirrored in colonial Australia, to some extent.

Despite the pioneering roles of Governors Gawler and Grey, the exigencies of colonial life in Adelaide meant that the practice of ethnography was important only so far as it contributed to the colonists' image of a new and strange land, or to an overlapping phase in which it was necessary to understand the Aborigines in order to control them more effectively. The early descriptions of Aboriginal life in South Australia and the published lithographs of watercolour studies by Angas catered for the first category of interest, primarily directed to a British readership. The ethnography of the missionaries and early Protectors such as Wyatt and Moorhouse was directed towards the more practical ends of the second phase. Moorhouse's Murray River vocabulary (1846) was constructed well after his Adelaide work, and was made at Grey's behest. In this sense it does not provide an exception to the general rule, by which other ethnographers followed their publications on grammar and vocabulary with more discursive works on manners and customs. Moorhouse and Teichelmann produced a joint 'Report on the Aborigines of South Australia' (published in January 1842) and Moorhouse was solely responsible for the 'Annual Report of the Aborigines' Department' (unpublished until 1991, see Foster 1991). The concentration of ethnographic research and publication in Adelaide during this second phase was markedly higher than in other colonies, a fact which throws the decline in ethnographic enquiry during the 1850s and 1860s into greater relief. Following the publication of Moorhouse's vocabulary in 1846, eighteen years passed before the next South Australian linguistic publication appeared—George Taplin's first work on Lower Murray River languages (1864).[14]

The reasons for this concentrated burst of activity are two-fold. In the first place, because of the concern expressed in England during the late 1830s by Lord Glenelg and the Colonial Office about the mistreatment of indigenous peoples, and partly because of the concentration on this issue by the key individuals associated with the colony of South Australia, Aboriginal matters were of greater concern for South Australian policy-

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[11] *Register*, 24 April, 1844, p.3. See also *Adelaide Observer*, 27 April, 1844, p.5.

[12] *Southern Australian* 5 September, 1843, p.2; GRG 24/4/1847/195; 205; 1430; 1462, State Records, South Australia.

[13] Smith 1984: 220. Smith makes this point in relation to Sydney artists of the 1790s and 1800s; the same shift can be observed in Adelaide's colonial period, three decades later. See also Dutton (1974).

[14] Teichelmann produced an unpublished, extensive, revised version of his Adelaide vocabulary during this period; this was sent to George Grey in Cape Town in 1857 (Teichelmann 1857 ms.). The vocabulary published by E. M. Curr in 1886 (Teichelmann, Schurmann & Wyatt 1886) is a much shorter wordlist.

makers.[15] This sensitivity accounts for the extended but ultimately unsuccessful efforts to fill the post of Protector of Aborigines with the 'conciliator' of Tasmanian tribes during the 1820s, George Augustus Robinson.[16] It also explains the trouble to which George Fife Angas went to secure the services of Lutheran missionaries prepared to learn the languages of the South Australian Aborigines in order to impart Christian principles to their children. In their attempts to explore the mental world of South Australian Aborigines, Teichelmann, Schurmann and Meyer went further than assembling simple word lists. Their expanded publications on the 'manners and customs' of Aborigines of Adelaide, Port Lincoln and Encounter Bay followed their scholarly work on the languages of these groups. For example, Teichelmann and Schurmann's grammar and vocabulary of the Adelaide Aborigines (1840) preceded Teichelmann's work on their manners and customs (1841) published in the following year, and Schurmann's vocabulary of the Parnkala people of Spencer's Gulf (1844) preceded his general work on the Aborigines of Port Lincoln (1846). Schurmann's ethnographic work with Port Lincoln Aborigines can be regarded as part of his duties as Protector of Aborigines there. Meyer's vocabulary of South Australian Aborigines (1843) preceded his work on the manners and customs of Encounter Bay Aborigines (1846).

Philology And 'The Abstract Science Of Man'

For a decade following the creation of the colony in 1836, the level of South Australian ethnographic activity exceeded that of any other colonial outpost throughout the world. At least thirteen vocabularies, four grammars and six descriptive works on South Australian Aboriginal manners and customs were produced. The vocabularies were by Bromley, Stevenson and Finlayson (unpublished and untraced); Gell (Assistant Secretary to Governor Gawler) 1841; Meyer (1843), Moorhouse (1846), Piesse (1840), Schurmann (1844), Teichelmann (Teichelmann, Schurmann and Wyatt 1886), Teichelmann and Schurmann (1840), Weatherston (n.d.; see Hunt (1985: 38)), Williams (1839), Wyatt (Teichelmann, Schurmann and Wyatt 1886). The descriptive ethnographies were by: Angas (1847a; 1847b), Cawthorne (1926), Eyre (1845), Grey (1841a), Meyer (1846), and Schurmann (1846). Schayer's (1844) Berlin publication on the language, manners and customs of South Australian Aborigines was probably based on the work of the Dresden missionaries. In addition, it appears that other concerted ethnographic and linguistic work was undertaken, such as that by the surgeon Richard Penney in 1841 and by the police-trooper and Sub-Protector George Mason during the early 1840s (Lendon 1929: 24: & 31: 20–33). Proportionately, this level of output in Australian linguistics has not been equalled since.[17]

South Australia's evolution as a colony coincided with the early development of ethnography as an internationally accepted scientific discipline. The first documented use of the term 'ethnography', to mean 'the scientific description of nations or races of men, their customs, habits and differences' was in 1834, the foundation year of the South Australian Literary and Scientific Association.[18] From the beginning though, ethnography was far more than a descriptive exercise: like other branches of Enlightenment natural science it held great promise as a means of discerning the origins of humankind. Australian Aborigines provided a new and exciting field for ethnographers, but seldom as a people to be studied in their own right. Their primary ethnographic value lay in the data which an analysis of their characteristics could contribute to wider debates.

The focus of ethnographic study shifted back and forth several times during the nineteenth century, from physical description to philology, to

[15] The correspondence files of the South Australian Company, particularly those of its Director, George Fife Angas, are full of references to this crucial issue (PRG 174, Mortlock Library, Adelaide). See also further discussion of this point in Pope (1989). Following the recommendations of the 1837 'Report from the Select Committee on Aborigines' (1968 (1837)), Standish Motte (himself a member of the South Australian Literary Association), published his 'Outline of a System of Legislation for Securing Protection to the Aboriginal Inhabitants of All Countries Colonized by Great Britain' (Motte 1840).

[16] John Brown, a founding committee member of the South Australian Literary and Scientific Association in London, was a cousin of the celebrated missionary George Augustus Robinson who worked among Tasmanian Aborigines during the 1830s. During 1836 Brown agitated successfully for Robinson to become South Australia's Protector of Aborigines, but Robinson eventually decided against the position.

[17] The 1960s–70s produced a very high volume of linguistic publications but from a much wider pool of specialists (J. Simpson pers. comm. 1991).

[18] 'The Shorter Oxford English Dictionary': 685.

kinship studies and religion, to archaeology and material culture. Internationally, the emphasis during the first half of the century centred firmly on philological research.[19] This promised a level of methodological certainty and a potential for deductible results which other branches of anthropology lacked. For newly arrived settlers in the New World and Australia the question of how the native inhabitants came to be there was of particular interest. Posing this question in his 'Notes on the State of Virginia' in 1804, Thomas Jefferson had predicted that language would offer 'the best proof of the affinity of nations which can ever be referred to'. Forty-two years later, Henry Schoolcraft's 'Plan for the Investigation of American Ethnology', presented to the Smithsonian Institution in 1846, stressed the resilience of this notion:

> Philology is one of the keys of knowledge which, I think, admits of its being said that, although it is rather rusty, the rust is, however, a proof of its antiquity. I am inclined to think that more true light is destined to be thrown on the history of the Indians by a study of their languages than of their traditions, or of any other feature (Jefferson and Schoolcraft quoted in Hinsley (1981: 23).

Comparative philology had the added advantage of offering a method for tracing the origins and diffusion of the world's peoples within the relatively short chronology accepted within biblical orthodoxy. South Australia's third Governor, George Grey, was a significant contributor to debate on this subject, which remained the 'queen of the human sciences' until the late 1850s, when biblical chronology was undermined by the emerging acceptance of Darwinian theory, geological time and the new 'prehistoric' archaeology (Chapman 1985: 21–22; Crawfurd 1863). In the meantime though, the careful, scientific methodology of philologists such as Johann Forster, Samuel Marsden, Lord Monboddo, and Wilhelm von Humboldt paralleled the techniques employed by the rising generation of earth scientists, future evolutionists included. Charles Darwin's influential friend, the geologist John Herschel, drew the analogy: 'Words are to the Anthropologist what rolled pebbles are to the Geologist—battered relics of past ages often containing within them indelible records capable of intelligible interpretation' (Desmond and Moore 1992: 215).

In Adelaide during the 1840s the science of philology held similar promise for the colony's 'utopian socialists'. Addressing an audience of 1 000 in the Queen's Theatre, even the austere Advocate-General, William Smillie, reserved a prominent place for philological studies in Adelaide's cultural life:

> The student of human nature will also find an appropriate chapter on the *aborigines*. Many of their peculiar customs and superstitions, the analogical sense contained in their terms, and the structure of their speech, illustrate the abstract science of man, while etymologies may be collected to throw some light on their origins and history, as connnected with other races... (Smillie 1842: 437).

Another of South Australia's 'utopian socialists', Robert Gouger, devoted considerable space to the Aborigines in his publication about the colony, referring to the linguistic similarity between South Australian Aborigines and the 'Malays of Dampier Straits' as perceived by Mr Donovan, chief officer of the *Katharine Stewart Forbes* (Gouger 1838: 52–53). The emerging science of ethnography drew its data neither from social traits nor from a comparison and analysis of material culture, but from linguistic 'specimens'. All the attributes of scientific practice were satisfied by the new field of linguistics. Given the correct direction and technique, useful data could be gathered by amateurs who would gain the reward of knowing that each fragment collected would assist their scientific mentors in constructing a new picture of human origins. Unlike collectors of ethnographic objects, whose arrays of curiosities still bore no evident relation to European artefacts, amateur and scientific linguists shared the conviction of natural scientists that they were actively collaborating in a grand scheme.

With the decline of philological research and deductive enquiry after mid-century, more tangible types of evidence seemed called for. The historian William Chapman has noted that for some, 'these were the evidence of skeletal and cranial forms, either as measured or uncovered from the ground; for others, the evidence of archaeology more generally; but for Pitt Rivers, the privileged evidence was to be that based on the comparison of artifacts' (Chapman 1985: 22). Even so, ethnographic collecting did not achieve quick popularity. It was not until the final decades

[19] See Gascoigne (1994: 160–176) for an account of philology within the Enlightenment context.

of the century that the role of Australian museums as repositories for ethnographic objects came to be validated in terms of the contribution which those objects might make to the pursuit of ethnography, or to science in general. During the decade after South Australia's proclamation, the collection of linguistic information had been validated in just those terms. As an 'exact science of mental objects', philology provided the impetus for the first systematic application of Western scientific principles of classification to Aborigines. As the French philosopher Renan put it, philology was a scientific method to be used for arriving at 'the very system of things ... [it is] ... the exact science of mental objects. It is to the sciences of humanity what physics and chemistry are to the philosophic sciences of bodies (Renan 1890 (1848): 149).

The multitude of Aboriginal vocabularies and basic grammars collected from the colonial frontier during the middle years of the nineteenth century can be contrasted with the relatively casual collection of Aboriginal artefacts during the same period. Susan Pearce has suggested that such an inverse relationship between language and objects may have been characteristic of this era, implicit in the dual status of ethnographic objects as both 'real' and 'constructed' artefacts:

> The long-term trend of European thought, increasingly cogently expressed from the late seventeenth century onwards, is to give a low value to the material world as such, and to regard it as the fit place for the exercise of human reason and enquiry through which real knowledge will be constituted. On this reading, objects in general are the passive result of social action, and museum collections enshrine the results of objective enquiry which has yielded real understanding; in other words, the metaphorically constructed understandings have been seen as superior to the concrete, contextual reality of the things. An important aspect of this is the tendency to regard language, the prime medium for classification and reason, as the faculty which creates social structure, although as we have seen there is not an exactly parallel relationship between language and the material world (Pearce 1992: 257).

The rigour which characterised linguistic studies in this early period has its direct analogue in natural science, as Edward Said has observed:

> Science gives speech to things; better yet, science brings out, causes to be pronounced, a potential speech within things. The special value of linguistics (as the new philology was then often called) is not that natural science resembles it, but rather that it treats words as natural, otherwise silent objects, which are made to give up their secrets. Remember that the major breakthrough in the study of inscriptions and hieroglyphs was the discovery by Champollion that the symbols on the Rosetta Stone had a phonetic as well as a semantic component. To make objects speak was like making words speak, giving them circumstantial value, and a precise place in a rule-governed order of regularity (Said 1978: 140).

But this 'circumstantial value' was not attached to ethnographic objects by museum scientists until the third quarter of the nineteenth century. The shift of status which eventually occurred during that period is best symbolised by the replacement of the descriptive term 'curio' by the phrase 'ethnographic specimen', carrying the implication that the classifications and strategies applied to natural objects by museum scientists could equally be applied to artefacts. Until that point was reached philology or linguistics remained the only branch of ethnography accorded scientific status. With few exceptions this field remained beyond the confines of the newly established natural history museums in Europe and Australia.

South Australia's early ethnographic studies, and similar researches in other Australian colonies, have been enlisted by historians of anthropology in describing the developing picture of the country's anthropological discipline (See for example, McCall 1982; Mulvaney 1964; 1993; Peterson 1990; Tindale 1986). In his subdivision of Australian anthropological history, A.P. Elkin placed the work undertaken during the colonial period within an 'incidental phase', implying little continuity with succeeding periods (Elkin 1970: 6; 1963). McCall (1982) and Peterson (1990) accept this characterisation of early Australian anthropology. While there is no doubt that later ethnographers and anthropologists built upon the results of this early work, the phase does bear a distinct character, apart from the sense employed by Elkin. The phase can be distinguished by the pragmatic, utilitarian nature of the research which it generated. Almost all of the ethnographic pamphlets and booklets appearing in Adelaide during the 1840s were published in the name of science. Most of this output was directed towards practical, short term ends; to facilitate the tasks of administrators and missionaries in dealing with Aborigines in the colonial situation. This early ethnographic work can be regarded as a precursor of the applied anthropology undertaken for colonial administrations during the early twentieth century.

Each of the early Protectors of Aborigines

produced vocabularies of the Adelaide Plains or adjoining regions, not primarily as a contribution to the growing international corpus of such material, but as a means of undertaking their assigned duties. The English Parliamentary Select Commission on Aborigines (British Settlements) of 1837 had officially recommended that Protectors of Aborigines 'should be expected to acquire an adequate familiarity with the native language' and that 'the Protectors should be furnished with some means of making to the tribes occasional presents of articles either of use or ornament' ('Reports from the Select Committee on Aborigines'. 1968 (1837), vol.2, p.83). By the time that this directive was issued, South Australia's first two Protectors, George Stevenson and Captain William Bromley, had already prepared working vocabularies. By August 1837, when Bromley was replaced by William Wyatt, the colonial government had adopted the Select Commission's directive regarding Aborigines and advised the new Protector that 'no time should be lost in acquiring a knowledge of their native tongue'.[20]

Wyatt and his successor Matthew Moorhouse prepared vocabularies of the Adelaide and Murray River Aborigines (Wyatt 1879, 1886; Moorhouse 1846).[21] The Governor's secretary wrote to Wyatt in August 1839 following the Protector's enforced resignation, informing him that the governor 'had peculiar opportunities for observing the patient and scientific research with which you have investigated their language, and he has now in his possession an extensive and very valuable vocabulary of it compiled by you' (Lendon (n.d.) ms.: 212).

The Colonial Storekeeper, William Williams, who also collected Aboriginal artefacts at this time for the Colonization Commissioners, recognised the utility of publications which might assist government officials and employers to benefit from the labour of 'idle natives', while encouraging the civilising process. During early 1839 he compiled his own vocabulary of the Adelaide Aborigines and offered this for sale to subscribers, including Governor Gawler and other government officials and notables.[22] Until his removal from office in 1841, Gawler played a vital role in sponsoring ethnographic studies of this kind, encouraging and assisting the work of the Protectors (notably Moorhouse), the Lutheran missionaries, and Edward John Eyre.

The arrival of George Grey during 1841 to replace Governor Gawler lifted South Australian ethnography out of its short-term, utilitarian mould. An influential anti-slavery and Church Missionary Society advocate, the young cavalry captain had already undertaken substantial ethnographic and linguistic studies of Western Australian Aborigines before his South Australian appointment (Grey 1841a). On the basis of his Western Australian experiences he had written carefully on the issue of 'promoting the civilisation' of Australia's Aborigines (1841b). In the year of his arrival in South Australia, and two years before the foundation of the Ethnological Society in London in 1843, Grey published a paper on administering native peoples, his major anthropological conclusions on Western Australian Aborigines and a detailed dictionary of South-Western Australian Aboriginal dialects (Grey 1841a; 1841b; 1841c; see also Mulvaney 1964: 23–25). During his term as South Australia's Governor from 1841 to 1845, Grey's first interest remained Australian linguistics and his 1845 paper on this subject summarised the state of knowledge in this field, noting that South Australian researchers had adopted a common system of orthography (Grey 1845). The linguistic evidence suggested to Grey that 'this continent was peopled from the north-west, and that the lines of migration were along the coast and the great water drainages of this country' (ibid: 366).

Together with Threlkeld in New South Wales, Grey was a leading Australian figure in investigating the Indo-European hypothesis of Aboriginal origins. His conclusions were reinforced with the publication of J. C. Prichard's findings that the Australian language had affinities with that of the Tamils of southern India (Mulvaney 1964: 22). He was a strong critic of inconsistent or inferior research, noting that 'up to the present time we have had only very meagre vocabularies, collected by passing strangers, each of whom adopted his own system of orthography, and the comparisons formed from such

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[20] Colonial Secretary's Instructions to Protector of Aborigines, *South Australian Gazette and Colonial Register*, 12 August, 1837, p.1.

[21] Although Wyatt's vocabulary was not published until 1879, it was available for use in government circles on its completion in 1839. See *South Australian Government Gazette*, 7 June, 1839.

[22] Williams' advertisement appears in the *Southern Australian*, 27 March, 1839, p.2. A copy of this vocabulary is listed among the contents of Grey's papers held in the South African Library, Cape Town (Williams 1839). It was later published in Parkhouse (ed. 1923).

compilations must necessariy have been erroneous in the highest degree' (Grey 1841a, vol.2: 215–16). He stressed the importance of establishing consistent principles of orthography in recording Aboriginal languages as a means of adducing reliable evidence to support the Indo-European hypothesis and in this respect his encouragement of the linguistic work of South Australian Lutheran missionaries was a major contribution. This initiative began before his appointment as Governor, during his first visit to Adelaide in 1840. Tindale (1974: 3) asserts that Grey guided the Lutheran missionaries in the production of their linguistic work. Some evidence for this lies in Teichelmann's acknowledgment of discussions with Grey about Australian 'dialects' (Teichelmann & Schurmann 1840: vii, viii). But Schurmann also recorded the fact that although Grey gave valuable encouragement to Teichelmann and himself in publishing their grammar and vocabulary, it was Moorhouse who assisted in reading and editing their English text (Schurmann 1987: 104; Teichelmann & Schurmann 1840: viii). In fact, it is possible that Grey incorporated some of Teichelmann's and Schurmann's vocabulary within his own 1841 publication without acknowledgement (Grey 1841a: 212–15). Grey was also quick to adopt the modified Threlkeld 'South Sea' orthography used by Teichelmann and Schurmann in their work, and argued for its adoption by the Royal Geographical Society (J. Simpson, pers. comm. 1991).

Until Grey's arrival in South Australia the colony had no ethnographer of equivalent standing to Threlkeld, who combined local, practical linguistic studies with a commitment to ethnography as a developing international science (Threlkeld 1834: 185). By promoting ethnographic enquiry as a branch of science linked to other fields of philosophical enquiry, Grey helped to give the study of Aboriginal manners and customs a new relevance in the colony. His significance in Australian anthropological history lies in the fact that he bridged the gap between the applied ethnography of colonial administrators and the more scholarly, enquiring approach promoted by the Royal Society, subsequently adopted by both the Royal Geographical Society and the Anthropological Society of London.

Grey's style of ethnography, like that of the explorers Charles Sturt and Edward Eyre, had its origins in the British naval and exploration tradition. The Royal Society's 'Directions for Seamen, Bound for Far Voyages' were first published in 1665. Cook's instructions, based on these directions, included the obligation to 'observe the Genius, Temper, Disposition and Number of the Natives' (Smith 1984: 8,16). The earliest opportunity for British ethnographic study in South Australia arose on Matthew Flinders' voyage of exploration in 1801–2. In view of his thorough investigation of northern Australian Aboriginal implements, rock paintings and burial modes, it is unfortunate that Flinders had little contact with Aborigines in South Australia. The single vocabulary published in his expedition report was obtained at Caledon Bay, on the west coast of the Gulf of Carpentaria (Flinders 1886). The French voyage of Baudin and Peron to Australia coincided with Flinders' voyage and the two expeditions met in Encounter Bay on April 8, 1802. But the French and British observations of South Australian Aborigines were minimal in comparison to the wealth of data on Tasmanian Aborigines recorded by Baudin's expedition. As Rhys Jones has explained, during this period the French displayed a much greater commitment than the British to anthropological research, through the Societé des Observateurs de l'Homme. This is despite the fact that the Baudin expedition rarely approached the standards set in Degerando's detailed anthropological instructions and suggestions (Degerando 1969) or by Cuvier (quoted in Jones, R. 1988: 37).[23]

The earliest record of South Australian Aboriginal languages was made in Western Australia, by a colleague of Dumont d'Urville during his voyage in the *Astrolabe* (1826–29).[24] During his 1829–1830 Murray River expedition the explorer Charles Sturt made little use of his numerous opportunities to record Aboriginal language and customs, despite having been directed to 'note the description of the several people whom you may meet, the extent of their population, their means of subsistence, their genius and disposition, the nature of their amusements, their diseases and remedies, their objects of worship, religious ceremonies, and a

[23] For a useful discussion of the distinction between French and British anthropology at this time see Gascoigne (1994: 158–159).

[24] Dumont d'Urville 1830–35. Dumont d'Urville obtained his word list from a colleague, Gaimard, who had recorded several words from a South Australian Aborigine in Western Australia, possibly brought there by sealers (Simpson, 1996). See Gaimard (1833) for this vocabulary. Dumont d'Urville also made an ethnographic collection in Australia, identified by Sylviane Jacquemin and referred to in Kaufmann (1994: 125).

vocubulary of their language' (Sturt 1833, vol.1: 187–88). While he adhered to his other instructions regarding the collection and recording of natural science objects, Sturt collected very little ethnographic material and made few observations of Aboriginal life. Writing after his Central Australian Expedition of 1844–46, Sturt admitted: 'It might be thought that having been in the interior for so many months I ought to have become acquainted with many of the customs and habits of the people inhabiting it, but it will have been seen that they seldom came near us' (Sturt 1847, vol.2: 139–40):

Sturt's only records of exchange with Aboriginal people during the earlier expedition were references to bartering tomahawks, knives, pieces of iron and coloured ribbons for fish (see for example Sturt 1833, vol.1: 180; vol.2: 113). During his inland expedition though, two members of his party, Daniel George Brock and John Harris-Browne, made small collections, and part of the latter collection may have been received by the South Australian Museum in 1949.[25] Brock's contact with Aborigines on the expedition was relatively close and frequent, in contrast to his leader. Sturt's attitude towards Aborigines, like that of the influential surveyor G. W. Goyder twenty-five years later, appears to have been friendly but firm:

> if one or two of them were a little forward, I laid it to the account of curiosity and a feeling of confidence in their own numbers. But a little thing checked them, nor did they venture to touch our persons, much less to put their hands in our pockets, as the natives appear to have done, in the case of another explorer. It is a liberty I never allowed any native to take, not only because I did not like it, but because I am sure it must have the effect of lowering the white man in the estimation of the savage, and diminishing those feelings of awe and inferiority, which are the European's best security against ill treatment (Sturt 1847, vol.1: 77–78).

George Grey produced several manuscripts on Aboriginal material culture subjects, including 'basket making', 'utensils for carrying water', 'ornaments', and 'shields', presumably directed towards a major publication on South Australian Aborigines, never completed.[26] These papers were not simply descriptive. In his attempts to ascribe origins to styles and design motifs Grey prefigured the work of later ethnographers who elevated material culture studies to scientific status. Here again, Grey encouraged similar work, particularly that of George French Angas (as a protegé) and Edward John Eyre (as a rival). The twenty-three year-old Angas accompanied Grey on his vice-regal tour of the colony's south-east during January 1844, and his written observations reveal something of the more experienced ethnographer's influence. Even taking account of William Cawthorne's unacknowledged assistance, Angas's fine-grained artistic depictions of South Australian Aborigines and their artefacts set new standards for ethnographic realism within Australia. They met his stated objective of 'preserving true and life records of man and scenes, so quickly passing away ... by pictorial representation, to describe the most interesting and peculiar features of South Australia and its aboriginal inhabitants' (Angas 1847b: preface).

That verisimilitude was heightened in Angas's first major exhibition, at London's Egyptian Hall during April 1846, by the inclusion of 'costumes, implements, weapons and utensils, belonging to the Australians and New Zealanders'.[27] Angas had collected these artefacts during his travels in order to illustrate them at the journey's end. A critic from *The Times* commented on the exhibition's value as a documentary record, together with the accompanying 'antiquities': 'The views and portraits are far beyond the common class of pictures; as works of art they possess very great merit, but as connected with the antiquities and present character and manners of the country in which they were taken, they are almost invaluable'.[28]

A similar emphasis on the range and variation of Aboriginal material culture in southern South Australia was evident in Angas's narrative, 'Savage Life and Scenes in Australia and New Zealand' (Angas 1847a). The accent was further

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[25] See Jones file on the Gilbert Collection. The provenance of the collection is not clear and several objects appear to date from later in the century and from regions not visited by Sturt. Harris-Browne and his brother had pastoral interests throughout South Australia and the Northern Territory. Nevertheless, several of the objects conform to the type and style of manufacture observed for the north-east of South Australia, through which Sturt's second expedition passed during 1845.

[26] Grey manuscript collection, South African Library, Cape Town. Copies held in AIATSIS library, Canberra. The publication is referred to by William Cawthorne during 1843. See Foster (ed.) 1991: 22.

[27] *Illustrated London News*, 18 April 1846, p.253, quoted in Tregenza (1982: 13).

[28] *The Times*, 6 April, 1846, p.3c, quoted in Tregenza (1982: 17).

marked in the work of Edward John Eyre. The explorer's ethnographic investigations were advanced considerably following his appointment as Resident Magistrate at Moorundie on the River Murray in 1841. Here Eyre had the task of regulating relations between Aborigines and cattle overlanders following the bloody events of the Rufus River affray earlier in that year. Eyre used the opportunity to supplement the notes gathered on his Central and Western Australian explorations with detailed observations on the life and material culture of the Aborigines of the lower River Murray. Returning to England a matter of days before Angas's arrival in Adelaide, Eyre took with him a large collection of Aboriginal artefacts, stuffed animals, an aviary of parrots and an emu. He had also obtained the permission of his main informant, Tenberry, to take his son Warrulan and another Aboriginal boy, Koar, with him.[29] Perhaps this example provided Angas with an additional incentive to emulate the American watercolourist George Catlin's 'Indian Gallery' which had presented paintings, artefacts and Native American performers in London's Egyptian Hall during 1840 and 1841.

Many of Eyre's artefacts were collected by Edward Scott, his old friend, a fellow explorer and an associate at Moorunde. Scott shared Eyre's ethnographic interests and this collection, which included weapons, nets, fishing gear and ornaments, represented more than a casual assemblage of souvenirs. Uncertain of his next appointment, Eyre was probably serious when he informed Scott by letter that, 'when I get all odds and ends together, I shall almost be enabled to open a museum in Regent Street'.[30] Eyre's was among the first to recognise the value of collecting Aboriginal objects as empirical data which could supplement linguistic evidence for cultural origins and diversity. This recognition was at least partly inspired by George Grey. Eyre wrote:

> as Captain Grey judiciously remarks, if the comparison in such [linguistic] cases be extended, and the vocabulary of each enlarged, there will always be found points of resemblance, either in the dialects compared, or in some intermediate dialect, which will bear out the conclusion assumed. This view is still further strengthened, by including in the comparison the weapons, habits, customs, and traditions, of the various tribes ... No one individual can hope personally to collect the whole material required; but if each recorded with fidelity the facts connected with those tribes, with whom he personally came into contact, a mass of evidence would soon be brought together that would more than suffice for the purpose required (Eyre 1845, vol.2: 398, 411).

Even so, this passage makes plain the restricted, corroborative role of native artefacts in the developing science of ethnography at this time. Artefacts were still characterised as 'curiosities', not yet amenable to the levels of investigation and analysis which 'specimens of language' were receiving from philologists. Exceptions could be found: during his survey of the Australian coast undertaken between 1818–1822 Philip King collected and described material culture objects in some detail, notwithstanding the fact that his primary ethnographic instruction was to compile comparative vocabularies of all the tribes encountered.[31] Eyre's ethnography provides another significant example.

At the time of Eyre's publication, the British scientific expedition vessels H.M.S. *Fly* and H.M.S. *Rattlesnake* were cruising Pacific waters. The naturalist John MacGillivray accompanied both voyages and his Australian linguistic data gathered on the latter voyage contributed to one of the most influential works in philology, R. G. Latham's 'Elements of Comparative Philology' (1862). Despite the wealth of material culture objects encountered throughout the Pacific and northern Australia the anthropological research undertaken on the voyages was largely restricted to philology. Mulvaney notes the fact that despite the sixth volume of information published by the expedition being titled 'Ethnology and Philology', linguistics occupied all but a few pages: 'a few lines sufficed in every instance for a superficial account of the rich material culture of contemporary Pacific peoples' (Mulvaney 1964: 26). Yet just five years later in his account of the *Rattlesnake's* voyage, J. McGillivray published the first investigation into comparative material culture (Mulvaney 1964: 30). His discussion of the similarity between the Australian boomerang and an Egyptian boomerang in the British

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[29] See Eyre's correspondence to E.B. Scott, August to December 1844, PRG177/2, Mortlock Library, Adelaide.

[30] ibid, 30 November, 1844

[31] Both this and the following example are drawn from Mulvaney's 1964 survey of the history of Australian anthropology (Mulvaney 1964: 18–19, 22, 26).

Museum had two effects. It signalled the admissibility of material culture data as evidence to be investigated in tracing the history of peoples. More significantly perhaps, it drew attention to the future relevance of museum collections as a site for this investigation.

Grey, Angas and Eyre helped shift the character of Adelaide ethnography from its restricted basis in administrative practice to a more empirical style linked to wider trends. Grey's and Eyre's approaches in particular foreshadowed the 'survey method' of anthropology which became so popular later in the century. In contrast to the vocabularies and short works on 'manners and customs' produced in Adelaide, the work of these individuals was published in London for a wide readership. Unfortunately for the development of Adelaide ethnography, the nature of their talents and connections made it inevitable that their stay in Adelaide would be brief. While Grey can be said to have built on the work of Governor Hindmarsh in fostering the beginnings of Adelaide anthropology, he left no successor. A gap of almost two decades separated the publications of Eyre and Angas from the next detailed research on South Australian Aborigines—George Taplin's work on the Ngarrindjeri groups.

The trio left Adelaide within months of each other: Grey to become governor in New Zealand and then South Africa, Angas to travel further and to exhibit and publish his Australian and New Zealand watercolours in London (adding a further series of South African studies during 1847), and Eyre to England before becoming a lieutenant-governor in New Zealand two years later under Grey. Each of these men had formed important collections of Aboriginal material, but almost nothing is known of the subsequent history of these objects or, indeed, of the original circumstances of their collection. This is despite their extensive writings on Aboriginal material culture.

There is little doubt that Eyre, like Angas and Grey, collected Aboriginal objects partly to illustrate subjects discussed in his publications. He may have retained several of the items figured in his 1845 two-volume account within his private collection. But he may have had an additional motive for collecting ethnographic material, linked to his official role as Protector. By 1840 his counterpart in the Port Phillip Protectorate, George Augustus Robinson, was advising his sub-protectors in each Victorian district to encourage the manufacture of native artefacts for sale through agents appointed for the purpose. A Mr Lilly, based in Melbourne, acted as the main agent for this purpose until his retirement during September 1840. By July 1840 the volume of artefacts had provoked Robinson to advise that a scale of purchase prices be devised, so that Aborigines could 'receive in provisions or useful articles the full value of the money realised ... money on no account should be given to the Natives'.[32] Following Lilly's retirement the scheme appeared to lose momentum, and Robinson advised that the 'baskets, skins and other articles ... of Aboriginal industry are in future to be retained in store at the station, until a sufficient quantity be collected for transmission to Melbourne ... to be disposed of ... either by private bargain, public auction, public bazaar, or any other mode'.[33]

Eyre's advocacy of a similar scheme suggests that he was aware of Robinson's initiatives in this regard. He wrote: 'The elder natives should be led as far as could be, to make articles of native industry for sale, as baskets, mats, weapons, implements, nets etc., these might be sent to Adelaide and sold periodically for their benefit' (Eyre 1845, vol.2: 489). The idea went no further apparently; with Eyre's departure the link between ethnography and administration of Aboriginal affairs was broken. It was to be another two decades before South Australian Aborigines were actively encouraged to produce artefacts for sale, under George Taplin's administration at the Point MacLeay Mission.[34]

Angas's published account of his January 1844 expedition with Governor Grey refers to only two occasions on which he collected ethnographic items. Of the first Angas wrote: 'Mooloo, the native whom I met near the junction of the lake, parted with his mother's skull for a small piece of tobacco!'. This object was noted by William Cawthorne on Angas's return to Adelaide, shortly after Angas had drawn it for publication. Cawthorne described it incredulously as 'a human

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[32] G. A. Robinson to C. W. Sievwright, 20 July, 1840, quoted in Lakic and Wrench (1994: 37).

[33] G. A. Robinson to C. W. Sievwright, 18 July, 1840; 21 September, 1840, quoted in ibid: 36, 37.

[34] One of the first indications that Point MacLeay Aborigines were producing artefacts for sale appears in the *Observer*, 4 February, 1860, p.6.

skull plastered up here and there with gum for a PITCHER. The natives put a string through one part of the skull ... and so carry their water. The skull is cleanish outside but very black on the inside. It looks a curious thing for a domestic utensil. They are as bad as Lord Byron'.[35]

On the second occasion Angas recorded without comment the requirement of reciprocity implicit in dealing with objects on the frontier of contact:

> about twenty young men and boys came up to us, and lighted their fires close to our encampment. Their hair was mostly in curls, and had it not been for the grease and ochre with which they had bedaubed their heads, many of them would have displayed beautiful hair. We obtained specimens of it, and they insisted upon having locks of ours in return, which they carefully stowed away in their rugs (Angas 1847a, vol.1: 94, 134).

It is unlikely that the Aborigines regarded this occurrence as extraordinary; their own use of human hair for hair-string would have provided a context.

Immediately prior to his appointment as Secretary to the Australian Museum in Sydney in 1853 Angas donated twenty-one artefacts to that institution. Several of these may have been Aboriginal, although it is likely that the bulk of this and other ethnographic donations made by him consisted of African and New Zealand artefacts (Specht 1980: 8–9). Angas returned to South Australia by the time of the Museum's foundation but by then he had abandoned his interest in ethnology for the scientific description of shells. He acted as temporary Curator of the Adelaide Museum during Waterhouse's absence on MacDouall Stuart's expedition of 1861–62 and assisted in describing the shells collected on that expedition (Gill 1886: 44).

Four small grinding stones 'from Southern Australia, carried by the females in a bag slung at their side' were presented by Grey to the British Museum during his term as Governor of South Australia, possibly as part of a larger collection.[36] Grey also shared the nineteenth-century collector's interest in burial customs and artefacts. During his January 1844 expedition to the colony's south-east he removed two mummified bodies from burial platforms near Lake Alexandrina, later sending them to the Royal College of Surgeons in London (*Adelaide Observer*, 6 April, 1844, p.5). The skull of a South Australian Aborigine, used as a drinking vessel, was collected by Grey and sent to Owen at the British Museum during the early 1840s; this may have been the very object mentioned by Cawthorne (Gill 1907–8: 232–33). Grey continued to correspond with South Australian linguistic workers after his departure from Adelaide, receiving a revised version of Teichelmann's Adelaide vocabulary as late as 1858.[37] As Governor of South Africa, Grey made presentations of copper ores and 'a collection of [mineral] specimens' to the Adelaide Museum in 1857, and donated a New Zealand greenstone axe thirty-five years later from his South African home (Hale 1956: 6–7).[38]

The departure of Eyre, Grey and Angas marked the close of the first phase of South Australian ethnographic activity. The period had been characterised by a remarkable level of linguistic research and publication. While the products of this research helped to make evident the differences between local Aboriginal groups, and highlighted something of the complexity of their social structures, the results barely touched the sensibilities of those European immigrants who rapidly outnumbered and displaced the diminishing Aboriginal population. Against the governing perceptions of Aboriginal people as undifferentiated, marginal and primitive, the work of the colony's early ethnographers seems more exceptional. In that light, the subsequent lack of attention towards the collection and description of Aboriginal material culture was hardly remarkable.

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[35] Cawthorne Diary, Saturday, 3 February, 1844. Foster (ed.) 1991: 32–33.

[36] Museum of Mankind specimen documentation no. 1840-12-1 (1–4), Jones 1985 ms. Grey's note also reads: 'The magnet is sensibly affected by them'. It is not certain that these were collected by Grey in South Australia. The 1840 date, if correct, may indicate that they were obtained on his first, brief trip to the colony, or that they were collected in Western Australia, which would be consistent with the description, 'Southern Australia'. Artefacts which Grey collected during his governorship in New Zealand were presented to the British Museum in 1854 (Braunholtz 1938: 7). Grey was also an enthusiastic natural history collector, with several species named after him. See Appendices C,D,E,F in Grey (1841a).

[37] Pers. comm. J. Simpson, 1991.

[38] On taking up his post as Governor of South Africa in 1855, Grey became a firm advocate of the South African Museum in Cape Town (founded in 1825). He sought copper ores from South Australia for it, in exchange for those sent to South Australia.

References

Primary sources

CAWTHORNE, W. A. ms. Diaries and Journals ('Literarium Diarium'); Manuscript notes and sketches re the aborigines of South Australia; Aborigines and their customs; Sketch of the Aborigines of South Australia. Mitchell Library, Sydney.

JONES, P. G. (1985) ms. Notes on Australian ethnographic collections in Britain and German museums, Anthropology Archives, South Australian Museum.

JONES, P. G. (1996) ms. Computer database of 3240 collectors contributing to South Australian Museum, 1860 to the present, Anthropology Archives, South Australian Museum.

LENDON, A. A. (n.d.) ms. Notes on early Protectors of Aborigines, PRG 128/13/10, Mortlock Library of South Australiana, Adelaide.

TEICHELMANN, C. G. 1857) ms. Dictionary of the Adelaide dialect. George Grey Library, South African Library, Cape Town (Copy in AIATSIS library, Canberra).

Secondary sources

ANGAS, G. F. 1847a. 'Savage Life and Scenes in Australia and New Zealand'. 2 vols., Smith, Elder & Co., London.

ANGAS, G. F. 1847b. 'South Australia Illustrated'. Thomas McLean, London.

BOHRER, F. N. 1994. The Times and Spaces of History: Representation, Assyria, and the British Museum. Pp. 197–222 *in* D. J. Sherman and I. Rogoff (eds.) 'Museum Culture. Histories, Discourses, Spectacles'. Routledge, London.

CAWTHORNE, W. 1926. Rough Notes on the Manners and Customs of the Natives. *Proceedings of the Royal Geographical Society of Australasia, South Australian Branch* **27**: 44–77.

CHAPMAN, W. R. 1985. Arranging ethnology. A.H.L.F. Pitt Rivers and the typological tradition, Pp.15–48, *in* G. Stocking (ed.) 'Objects and others: essays on museums and material culture'. University of Wisconsin Press, Wisconsin.

CRAWFURD, J. 1863. On Sir Charles Lyell's 'Antiquity of Man' and on Professor Huxley's 'Evidences as to Man's Place in Nature'. *Transactions of the Ethnological Society of London* 3: 58–70.

DEGERANDO, J-M., (1969) (1800. 'The observation of savage peoples'. Routledge and Kegan Paul, London.

DESMOND, A. and MOORE, J. 1992. 'Darwin'. Penguin Books, London.

DUTTON, G. 1967. 'The Hero as Murderer. The Life of Edward John Eyre'. William Collins, Sydney.

DUTTON, G. 1974. White on Black. 'The Australian Aborigine Portrayed in Art'. Macmillan, Melbourne.

ELKIN, A. P. 1963. The development of scientific knowledge of the Aborigines. Pp. 3–28 *in* H. Shiels (ed.) 'Australian Aboriginal Studies'. Oxford University Press, Melbourne.

ELKIN, A. P. 1970 . The journal *Oceania*, 1930–1970. *Oceania Monograph* **16**. University of Sydney, Sydney.

EYRE, E. J. 1845. Manners and Customs of the Aborigines of Australia. Pp. 147–512 *in* E.J. Eyre, 'Journals of Expeditions of Discovery into Central Australia, and Overland from Adelaide to King George's Sound, in the Years 1840–41'. 2 vols. T. & W. Boone, London.

FLINDERS, M. 1886. [Language of Caledon Bay, Gulf of Carpentaria]. P. 276 *in* E. M. Curr (ed.) 'The Australian Race'. vol. 1, John Ferres, Melbourne.

FOSTER, R. 1991. Two early reports on the Aborigines of South Australia, *Journal of the Anthropological Society of South Australia* **28**(1): 38–39.

FOSTER, R. ed.. (1991. 'Sketches of the Aborigines of South Australia. References in the Cawthorne Papers'. Aboriginal Heritage Branch, South Australian Department of Environment and Planning, Adelaide.

GAIMARD, P. 1833. Vocabulaire de la langue des habitants de Golfe Saint-Vincent. Pp. 6–8 *in* J. S. Dumont d'Urville (ed.) 'Voyage de decouverte de l'Astrolabe 1826–1829 sous le commandement de M. J. Dumont d'Urville'. Vol. 1, Philologie. J. Tastu, Paris.

GASCOIGNE, J. 1994. 'Joseph Banks and the English Enlightenment. Useful Knowledge and Polite Culture'. Cambridge University Press, Cambridge.

GELL, J.P. 1841. The vocabulary of the Adelaide tribe. *Tasmanian Journal of Natural Science* **1**(2): 109–124. Reprinted in *Journal of the Anthropological Society of South Australia* **25**(5): 3–15.

GILL, T. 1886. 'Bibliography of South Australia: Colonial and Indian Exhibition in London, 1886'. The Author, Adelaide.

GOUGER, R. 1838. 'South Australia in 1837; in a Series of Letters: With a Postscript as to 1838'. Harvey and Darton, London.

GREY, G. 1841a. 'Journals of Two Expeditions of Discovery in North-West and Western Australia during the Years 1837–38, and 1839'. 2 vols. Borges & Co., London.

GREY, G. 1841b. A Report on the Best Means of Promoting the Civilization of the Aboriginal Inhabitants of Australia, *Papers and Proceedings of the Aboriginal Protection Society* **2**(5): 171.

GREY, G. 1841c. 'A Vocabulary of the Dialects of South-Western Australia'. London.

GREY, G. 1845. On the Languages of Australia, *Journal of Royal Geographical Society* **15**: 365–377.

HALE, H. M. 1956. The First Hundred Years of the South Australian Museum 1856–1956. *Records of the South Australian Museum* **12**: 1–226.

HINSLEY, C. M. 1981. 'Savages and scientists: the Smithsonian Institution and the development of American anthropology'. Smithsonian Institution Press, Washington D.C.

HUNT, A. D. 1985. 'This side of heaven. A history of Methodism in South Australia'. Lutheran Publishing House, Adelaide.

JONES, R. 1988. 'Images of Natural Man'. Pp. 35–64 *in* J. Bonnemains, E. Forsyth & B. Smith (eds.) 'Baudin in Australian Waters. The Artwork of the French Voyage of Discovery to the Southern Lands 1800–1804'. Oxford University Press, Melbourne.

KAUFMANN, C. 1994. Review of Jacquemin, S. 'Objects des mers du sud. Histoire des collections océaniennes dans les musées et établissements parisiens. XVIIIeme – XXeme siècles'. Ecole du Louvre, Memoire de récherche, sous la direction de Monsieur le Professeur Jean Guiart, 1991, manuscrit dactylographie, *Pacific Arts*, **9,10**: 125–128.

LAKIC, M. & WRENCH, R. (eds.) (1994. 'Through Their Eyes. An Historical Record of Aboriginal People of Victoria as Documented by the Officials of the Port Phillip Protectorate, 1839–1841'. Museum of Victoria, Melbourne.

LATHAM, R. G. 1862. 'Elements of Comparative Philology'. London.

LEIGH, W. H. 1839. 'Reconnoitering Voyages and Travels with Adventures in the New Colony of South Australia'. Smith, Elder & Co, London.

LENDON, A. A. 1931. Dr Richard Penney, 1840–44. *Proceedings of the Royal Geographical Society of Australasia, South Australian Branch* **31**: 20–33.

MCCALL, G. 1982. Anthropology in Australia: introductory remarks, Pp. 1–21 *in* G. McCall (ed.). 'Anthropology in Australia: Essays to honour 50 years of *Mankind*'. Anthropological Society of New South Wales, Sydney.

MEYER, H. A. E. 1843. 'Vocabulary of the Language Spoken by the Aborigines of South Australia'. Adelaide.

MEYER, H. A. E. 1846. 'Manners and Customs of the Aborigines of the Encounter Bay Tribe'.Reprinted pp. 183–206 *in* J. D. Woods (ed.) 1879 'Native Tribes of South Australia', E. S. Wigg & Son, Adelaide

MOORHOUSE, M. 1846. 'A Vocabulary and Outline of the Grammatical Structure of the Murray River Language'. Reprinted in *Journal of the Anthropological Institute* **1** (1871): 88; *Journal of the Proceedings of the Royal Society of New South Wales* **20** (1886): 64–68.

MOTTE, S. 1840. 'Outline of a System of Legislation for Securing Protection to the Aboriginal Inhabitants of All Countries Colonized by Great Britain'. London.

MULVANEY, D. J. 1964. The Australian Aborigines 1606–1929: Opinion and Fieldwork. Pp. 1–56 *in* J. J. Eastwood and F. B. Smith (comp.) 'Historical Studies. Selected Articles'. Melbourne University Press, Melbourne.

MULVANEY, D. J. 1993. Australian Anthropology: Foundations and Funding, *Aboriginal History* 17: 105–28.

PARKHOUSE, T. A. 1923. (ed.) 'Reprints and Papers Relating to the Autochthones of Australia'. The Author, Woodville.

PEARCE, S. M. 1992. Museums, 'Objects and Collections: A Cultural Study'. Leicester University Press, Leicester.

PETERSON, N. 1990. The history of the institutionalisation of Aboriginal anthropology. *Australian Aboriginal Studies* **2**: 3–19.

PIESSE, L. 1840). The Language of the Natives of South Australia. *The South Australian Colonist* 1(19): 295–296.

POPE, A. 1989. 'Resistance and Retaliation. Aboriginal-European Relations in Early Colonial South Australia'. Heritage Action, Bridgewater.

REECE, R. H. W. 1974. 'Aborigines and Colonists. Aborigines and Colonial Society in New South Wales in the 1830s and 1840s'. Sydney University Press, Sydney.

RENAN, E. 1890 (1848). 'L'Avenir de la Science: Pensées de 1848'. Calmann-Levy, Paris.

'Report from the Select Committee on Aborigines (British Settlements)'. (1968) (1837) Irish University Press Series of British Parliamentary Papers. Vol. 2. Irish University Press, Shannon.

SAID, E. 1978. 'Orientalism'. Pantheon Books, New York.

SCHAYER, L (1844. Uber Sprache, Sitten und Gebrauche der Urbewohner von Sud-Australien. *Monatsberichte (Verhandlungen) der Gesellschaft Erdkunde* 189–195.

SCHURMANN, C. W. 1844. 'A Vocabulary of the Parnkalla Language as Spoken by the Natives of Spencer's Gulf'. Thomas, Adelaide. Reprinted in *Journal of the Anthropological Institute* **1** (1888), and *Journal of the Proceedings of the Royal Society of New South Wales* **20** (1886): 64–68.

SCHURMANN, C. W. 1846. 'The Aboriginal Tribes of Port Lincoln'. Adelaide. Reprinted Pp. 207–52 *in* J. D. Woods (ed.) (1879) 'Native Tribes of South Australia', E. S. Wigg & Sons, Adelaide.

SCHURMANN, T. 1987. 'I'd rather dig potatoes'

[biography of C. W. Schurmann, Lutheran missionary]. Lutheran Publishing House, Adelaide.

SIMPSON, J. 1996. Early language contact varieties in South Australia. *Australian Journal of Linguistics* **16**(2): 169–207.

SMILLIE, W. 1842. Mental Culture. Introductory Discourse to the South Australian Literary and Scientific Association and Mechanics' Institute, 26 July, 1842. *South Australian Magazine* **11**(2): 430–438.

SMITH, B. W. 1984. 'European vision and the South Pacific'. Harper and Row, Sydney.

SNELL, E. 1988. 'The Life and Adventures of Edward Snell'. (Edited and introduced by T. Griffiths) Angus and Robertson, Sydney.

SPECHT, J. 1980. 'Lasting memorials': the early years of the Australian Museum, *Australian Natural History* **20**: 7–11, 31.

STURT, C. 1833. 'Two Expeditions into the Interior of Southern Australia'. 2 vols., Smith, Elder & Co., London.

STURT C. 1847. 'Narrative of an Expedition into Central Australia During the Years 1844–46, Together with a Notice of the Province of South Australia in 1847'. 2 vols., T. & W. Boone, London.

TAPLIN, G. 1864. 'Lessons, Hymns and Prayers for the Native School at Point Macleay in the language of the Lakes Tribes of Aborigines, called Narrinyeri'. Adelaide.

TEICHELMANN, C. G. 1841. 'Aborigines of South Australia. Illustrative and Explanatory Note of the manners, customs, habits, and superstitions of the Natives of South Australia'. Thomas & Co., Adelaide.

TEICHELMANN, C. G. and SCHURMANN, C. W. 1840. 'Outlines of a Grammar, Vocabulary, and Phraseology of the Aboriginal Language of South Australia, Spoken by the Natives in, and for Some Distance around, Adelaide'. Thomas & Co, Adelaide.

TEICHELMANN, C. G., SCHURMANN, C. W. and WYATT, W. 1886. Adelaide and its neighbourhood [vocabulary]. Pp. 148–151, *in* E. M. Curr (ed.) 'The Australian Race'. 4 vols. John Ferres, Melbourne, vol.3.

THRELKELD, L. E. 1834. 'An Australian Grammar Comprehending the Principles and Natural Rules of the Language as Spoken by the Aborigines in the Vicinity of Hunter's River, Lake MacQuarie, New South Wales'. Sydney.

TINDALE, N. B. 1974. 'Aboriginal Tribes of Australia. Their Terrain, Environmental Controls, Distribution, Limits and Proper Names'. University of California Press, Berkeley.

TINDALE, N. B. 1986). Anthropology. Pp.235–249 *in* C. R. Twidale, M. J. Tyler and M. Davies (eds.) 'Ideas and Endeavours—The Natural Sciences in South Australia'. Royal Society of South Australia, Adelaide.

TREGENZA, J. 1982. 'George French Angas. Artist, Traveller and Naturalist 1822–1886'. Art Gallery Board of South Australia, Adelaide.

WILLIAMS, W. 1839. 'A vocabulary of the language of the Aborigines of the Adelaide district, and other friendly tribes, of the province of South Australia'. MacDougall, Adelaide.

WYATT, W. 1879. Some Account of the Manners and Superstitions of the Adelaide and Encounter Bay Tribes. Pp. 157–181 *in* J. D. Woods (ed.) 'The Native Tribes of South Australia', E. S. Wigg & Son, Adelaide.

WYATT, W. 1886. Adelaide District: Vocabulary. Pp. 148–152 *in* E. M. Curr. (ed.) 'The Australian Race' vol. 2. John Ferres, Melbourne, vol. 3.

A STAUNCH BUT TESTING FRIENDSHIP: DOUGLAS MAWSON AND T. W. EDGEWORTH DAVID.

D. W. CORBETT

CORBETT, D. W. 2000. A staunch but testing friendship: Douglas Mawson and T.W. Edgeworth David. *Records of the South Australian Museum* 33(1): 49–70.

Sir Douglas Mawson and Sir T. W. Edgeworth David enjoyed a long and fruitful friendship which began when Mawson was a student at the University of Sydney and continued until David's death in 1934. The relationship developed from that of teacher-student to expedition colleagues in the Antarctic and on to academic equals bonded by a passion for geology and the pursuit of scientific truth. Differences in character and temperament made the two men unlikely friends, but a strong bond of respect and affection enabled them to overcome the not infrequent tests of equanimity, particularly on Mawson's part. The connections they made and the influences they exerted across Australia in the days before air travel and e-mail mark an important phase in the development of a continental perspective on Australian geology and its emergence on the world stage.

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T. W. Edgeworth David (1858–1934) was Australia's foremost geologist in the early decades of the twentieth century (Fig. 1). He was appointed Professor of Geology and Physical Geography at the University of Sydney in 1891 and his department was the first in Australia to train students for a professional career in geology. David was a gifted and dynamic teacher, an adventurous and energetic field worker and a prolific writer on geological themes, popular as well as scientific. His most ambitious project, a synthesis of the geology of Australia remained unfinished at his death in 1934. Aspects of David's life and achievements are covered in important reviews by Branagan (1973, 1981, 1985) and Carey (1990).

Douglas Mawson's long association with David began in 1899 when he entered the University of Sydney as a sixteen year old undergraduate. For the next thirty five years, until his death in 1934, David was in turn Mawson's teacher, mentor, colleague, confidant and friend. Their relationship was not always smooth, in part a measure of their age difference (twenty-four years), and their marked contrast in character. David was the quintessential Victorian gentleman, courteous, charming and erudite, wearing his heart on his sleeve and with a flair for publicity. Mawson although less outgoing was generous hearted with a friendly disposition, but inclined to reticence and introversion at times. Both were sensitive by nature, David particularly so, and at times this led to misunderstanding and over-reaction to real or imagined slights. Yet despite their differences, the friendship stood firm, surviving the hardships of Antarctic exploration, the upheavals of the First World War, and academic lives lived half a continent apart. It was a friendship sustained by regular contact at scientific meetings around Australia and David, an inveterate traveller, was a regular visitor to Mawson's home in Adelaide. Their correspondence, drawn upon freely in this paper, throws much light on the relationship between the two men. Unfortunately the surviving correspondence is markedly unbalanced, with few of Mawson's letters surviving in the David archive.

Mawson and the University of Sydney 1899–1905

Mawson began his studies at the University of Sydney as an engineering student. At that time the Engineering Department was part of the Faculty of Science and there were strong ties between Engineering and the newly established, and government supported, School of Mines. By Mawson's time the Geology Department was well housed and equipped and attracting a growing number of students, many of them, like Mawson, from Engineering; first year Geology being a compulsory subject for all engineering students. David himself was responsible for most of the

FIGURE 1. T. W. Edgeworth David, (1858–1934). (Photo: University of Adelaide.)

geology teaching with assistance in mineralogy and petrology from W. G. Woolnough (from his graduation in 1898 until 1901 when he moved to Adelaide) and H. S. Jevons (1901–05) (Branagan 1985: 129). Mineralogy courses, formerly part of Chemistry had been transferred to Geology with the re-organisation of the Geology Department so that Mawson in his early University years was exposed to a curriculum strong in geology, mineralogy and mining – all subjects which were to influence his later career.

David's wide-ranging interests and early experience, both in Britain and later with the New South Wales Geological Survey before joining the University, were reflected in his courses which covered physical and general geology and included lectures on Australian geology. Laboratory studies, both microscopic and chemical, were also introduced. Courses were strongly field-oriented, students being introduced to the pleasures of field work at an early stage of their careers.

One of David's prime interests was in the geological evidence for past glaciation. When he was a student at Oxford in the late 1870s the nature of glacial processes was still a new and hotly debated topic on which there was little general agreement. His first published papers (in the *Journal of the Cardiff Naturalists' Society*) were on the evidence for glaciation in South Wales and based on his own fieldwork. Subsequently, in 1887, when working for the New South Wales Geological Survey, he identified glacial sediments in the Permo-Carboniferous rocks of the Hunter Valley (David 1897), while in 1901 he confirmed the evidence for glacial action on Mount Kosciusko (David *et al.* 1901). In the same year, during Mawson's third year at the University, Walter Howchin, in South Australia, announced the discovery of glacial rocks of presumed Cambrian age in the Sturt Gorge south of Adelaide (Howchin 1901).

David had a strong interest in South Australian geology: he and Howchin had discovered the first Cambrian fossils in the Mount Lofty Ranges in 1896 (Howchin 1897). A Permo-Carboniferous age for the Hallett Cove and Inman Valley glacials having been established by this time (David & Howchin 1897), the recognition of two widely separated glacial events focussed attention on the significance of glaciation in the South Australian geological record, which was to have important implications for Mawson. Given David's strong interest in ancient glaciation it would surely have been a hot topic of discussion in the Sydney department and it seems likely that Mawson's own interest was kindled at this time. However his early enthusiasms were for mineralogy and petrology. He was awarded the Petrology Prize in 1901 and completed the coursework for his B.E. in Mining and Metallurgy in 1901. With David's support he was appointed Junior Demonstrator in Chemistry in 1902, and collaborated with T. H. Laby on a geochemical investigation of the radioactive properties of Australian minerals (Mawson & Laby 1904)

In 1903, on David's recommendation, Mawson took six months leave of absence to undertake a ship-based reconnaissance survey of the New Hebrides archipelago, a highly adventurous trip into a little known area. The expedition gave him valuable field experience under trying conditions and he proved himself a resourceful and perceptive field worker, qualities developed later in his career as an explorer and academic geologist (see Corbett

FIGURE 2. Douglas Mawson, (1882–1958).

1997: 110–112). His published report (Mawson 1905) was the first comprehensive account of the geology of the islands. Mawson's correspondence with David began on this trip and his enthusiasm and persistence are well shown in a letter from Tangoa on Santo (3 July 1903): '...have seen a good deal of S. Santo but have found no trace of any really old rocks'. He confides to David that he and his companion Harold Quaife deceived Captain Rason, the expedition commander, pretending to stay at a missionary's house knowing they would have been refused permission to climb the highest mountain on Santo. In the event conditions proved difficult and they did not reach the summit, but the geology was interesting and the mountain was found to be 'the ruined cone of an old volcano'. Mawson returned to Sydney in September 1903 to write his report and resume his research projects and coursework towards his B.Sc., which he completed, majoring in geology in 1904, graduating in 1905.

New Fields

In 1904, W. G. Woolnough resigned from the position of Lecturer in Mineralogy and Petrology at the University of Adelaide and returned to Sydney. With David's backing, Mawson applied for the position and was appointed, moving to Adelaide and taking up his duties early in 1905. David doubtless viewed the appointment of his former student to the Adelaide Department as a further strengthening of his ties with South Australian geology. His old friend Walter Howchin now became Mawson's lecturing colleague in the small Department. Differences in age, temperament and areas of interest allied to a strong perception that Howchin held a proprietary interest over much of South Australia led Mawson to choose a distant and relatively unknown area, the border country between South Australia and New South Wales in the Olary–Broken Hill region for fieldwork and research. It proved an astute choice; for it is a highly mineralised region of ancient crystalline rocks which provided abundant scope for his mineralogical and petrological interests (Mawson 1912). Among the numerous mineral occurrences was a recently discovered radioactive deposit which Mawson was the first to investigate fully and which he named Radium Hill. A new and complex mineral which he found there—a titanate of iron, uranium and rare earths—he named davidite after his former Professor (Mawson 1906).

Of particular significance in the Olary region, the igneous and metamorphic basement rocks are overlain by a sedimentary sequence of great antiquity which Mawson was able to relate to similar rocks closer to Adelaide, thus complementing some of Howchin's stratigraphic work in the Mount Lofty Ranges. It was his identification of thick glacial deposits within the sedimentary sequence which not only suggested correlation with the Sturt Tillite but re-kindled Mawson's interest in glacial rocks and processes leading to his first Antarctic adventure and the beginning of a lifelong concern with glaciation. That Mawson dated his involvement from that time is confirmed in a letter written to David many years later (25 June 1934), only two months before David's death, in which Mawson recalls a meeting in Adelaide with Dr. Caldenius, a European glacial geologist. Howchin was present at the time and evidently irritated Mawson, prompting the comment 'He [Howchin] does not appear fully to appreciate details of our older glacial series—as he talks of measuring up all the

FIGURE 3. Australasian Association for the Advancement of Science (AAAS) group photograph, Adelaide, January 1907. Included are David (front row, 11th from left), Mawson (back row, third from right), and Howchin (front row, 9th from left).

varve beds in the State—that job is more than a lifetime's work. I explained that I had been specially interested in these beds and regularly collecting data thereon since December 1906—and that it was my desire to better understand fluvioglacial sedimentation that caused me to seek a trip to the Antarctic with Shackleton'.

Mawson, perhaps prompted by David, seized the opportunity to meet Shackleton when he passed through Adelaide in January 1907 (see also Fig. 3). In the event his involvement in the expedition did not quite go the way he had planned, as he was to note later in his diary: 'In the first place, believing the Prof. [i.e. David] to be remaining in Antarctica for whole time, I asked only to go on voyage down—and that in 1909... Without any correspondence on subject the Prof wired me: appointed Physicist to Expedition and report at once. Now this is hardly what I wanted as, though I should have embraced the opportunity of stopping whole time as Geologist, I did not like the idea of physicist. However, after asking the advice of friends and now hearing from the Prof. that he and Cotton were only going down with the ship, I agreed to go... Now, when halfway to Antarctica, the Prof. decides to stay— he can do geology, I cannot' (Jacka & Jacka 1991: xxvii).

South with Shackleton

Despite Mawson's early misgivings about his role down south, David involved Mawson in the geological work from the start and the two shared quarters in the expedition's base hut at Cape Royds at the foot of Mount Erebus. When David convinced Shackleton that an attempt to make the first ascent of the mountain before winter set in would have scientific value as well as being a useful exploratory exercise, Mawson was included in the party which made the ascent. He was responsible for collecting geological samples as well as for the photographic work. It took the six man party three days and two nights of blizzard conditions to reach the rim of the old summit wall. David and Mawson with McKay then descended to the crater floor, and climbed the inner, active cone, looking down into the vent from which steam was rising accompanied by a loud hissing noise and periodic dull booms (Fig. 4). They calculated the height of the mountain to be 13 370 feet (4075m) above sea level.

The short but difficult journey yielded much interesting geological information (see David & Priestley 1914) and its success probably influenced Shackleton in selecting the same team of David, Mawson and McKay, designated the Northern Party, to undertake the journey to the South Magnetic Pole. There is a certain ambivalence in Shackleton's instructions to the party, for while the achievement of the Magnetic Pole is given first priority, the geological objectives are also stressed, including a survey of the coast of Victoria Land and the Western Mountains (Fig. 5), while on the return journey Mawson is given explicit instructions to investigate Dry Valley as a matter 'of supreme importance' and to prospect for minerals of economic value. Shackleton, most probably under David's influence, was now utilising Mawson for his geological skills, realising that the David-Mawson combination made a formidable team.

It was always going to be a tough assignment and there were tensions in the party from the beginning. Mawson was frequently frustrated and irritated by David's somewhat eccentric habits and behaviour and his physical inability to keep up with his younger colleagues, who consequently had to literally shoulder more of the burden of sledge hauling. There is no doubt that David did his best (he was then fifty years of age) and that he in fact overtaxed himself while carrying out his duties to the best of his ability, but the fact remained that his condition did place an enormous burden on his colleagues. While Mawson confined his frustrations to his diary and a rare verbal exchange, it appears that McKay was more directly abusive to his companion, reaching a point where he was prepared to certify David insane, and urging Mawson to take over the leadership of the party. It was a step Mawson was reluctant to take. While David at the end of their ordeal confided to Mawson that he had considered Mawson as leader from early in the expedition, in fact David (with McKay) had decided to push for the Magnetic Pole against the opinion of Mawson who was all for abandoning this to concentrate on the scientific objects of the journey (Jacka & Jacka 1991)

The Magnetic Pole journey was a gruelling adventure which could well have had a less satisfactory outcome. The three were perhaps fortunate to survive and there is no doubt that it was Mawson who held the small party together. Nevertheless, despite the difficulties, the two geologists were able to collect a considerable amount of geological information during the earlier part of the trip and Mawson is given due recognition in the final report (David & Priestley 1914). Perhaps most significantly, at no time during the entire expedition did Mawson lose his

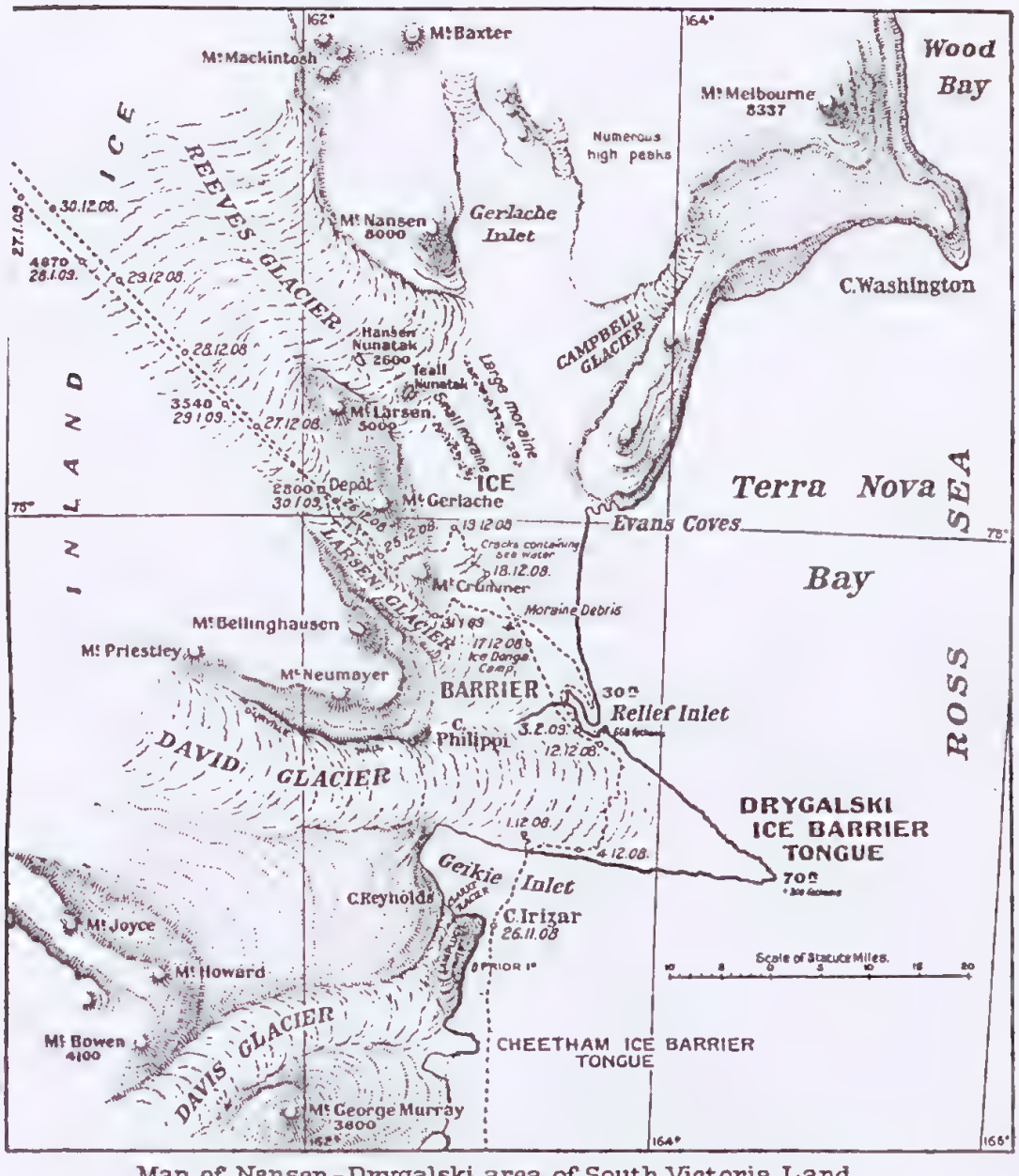
FIGURE 4. The active crater of Mount Erebus, taken from the lower part of the crater edge. (Photo: D. Mawson, from David & Priestley 1914).

respect for the man who was dubbed 'The Prof.' by the expedition, and he was quick to recognise that, despite his idiosyncrasies, David always gave of his best and had the success of the expedition at heart. To Priestley, the other geologist on the expedition, David was 'a tower of strength' who was 'in spirit the youngest man in a very youthful company'.

The Stressful Years

Soon after the expedition returned to Australia, David wrote to Mawson (7 September 1909), discussing plans for the writing up of the results. David had all the geological specimens in Sydney and was relieved that Shackleton had not requested any to be sent to London. Mawson was to describe the southern journey rocks, and other likely contributors had to be found. Meanwhile Mawson still had to finish off his Olary-Broken Hill work but was already arranging leave of absence for a trip to Europe. For Mawson, the Shackleton Expedition marked the beginning of a lifelong involvement with Antarctica. For the next ten years the southern continent and the First World War were to occupy the greater part of his time while University matters of necessity

PLATE IX



Map of Nansen-Drygalski area of South Victoria Land showing Coast, Horst, outlet Glaciers, & Inland Ice.
Chiefly after Survey by Dr Mawson.

FIGURE 5. Map of part of the route taken by the South Magnetic Pole Party. (From David & Priestley 1914.)

assumed a subsidiary role. Before Mawson left on his Australasian Antarctic Expedition in late 1911, David wrote to him:

> My dear Old Mawson,
>
> Just a few words to bid you and all yours God Speed, and wish you all safe return. You have a great and perilous venture before you; may (you) be spared to come through it all unscathed and to return full of honour and gain to Science. My heart goes with you all. Ever my dear man, your affectionate old comrade.
>
> T. W. Edgeworth David.

The AAE expedition did indeed prove a perilous venture for Mawson and he was not to come through it unscathed, but it marked an important episode in Antarctic exploration with significant geographic and scientific results which established Mawson as an expedition leader of the first rank and a pioneer in the use of the new technology of radio. Mawson returned to Adelaide on 26 February 1914.

In a letter (15 November 1913) David, anticipating Mawson's earlier return, had written: 'There is so much to talk about that one hardly

knows where to begin', and he 'eagerly awaits' details of Mawson's expedition, noting that 'the whole word has been intensely moved by the two great Antarctic tragedies' (i.e. that of the Scott party as well as Mawson's loss of Ninnis and Mertz). He was full of enthusiasm for the geographic and scientific discoveries made by the AAE, 'which have added King George V Land and Queen Mary Land to the map'; while 'there are all the biological, geological and glaciological results, your physical observations and the magnetic results, which should prove of the highest interest'.

Both Mawson and David volunteered for war service. David, though now 57 years old, was attached as an officer to a Mining Battalion and later as geologist attached to the General Headquarters of the British 1st Army. On the Western Front he was involved in drainage tunnelling and water-supply problems and trenches construction, and his expertise was recognised to the extent that he was appointed Chief Geologist of the British Armies (Carey 1990).

For Mawson, the war began before he had fully recovered from the traumatic and debilitating experiences of his expedition and while he was still extremely busy with post-expedition matters. After initial difficulties in securing a suitable position (MacLeod 1988), he spent two years in a highly responsible administrative post with the War Office in London during which time David and Mawson managed to keep up their correspondence. David was particularly concerned with the publication of the results of the BAE, writing to Mawson in London from the headquarters of the Australian Mining Corps in France (11 July 1916): 'It is very good of you to take on the work of seeing this Vol. II of Antarctic Geology when you are otherwise so busy. There is a lot of real good stuff in it, and it has been unfair to the authors to keep back so much good material from publication. It will be great relief to me when the vol., is published.' On 23 August he mentioned the 'nerve wearying work' and the strain of being 'more or less under fire about every other day, and I have had four months of it now, but am keeping very well, I am thankful to say'.

Mawson replied (17 September 1916) discussing BAE matters and criticising Shackleton, relations with whom had deteriorated after their return from the South and notably since Shackleton's ambivalence on plans for further explorations, which had resulted in Mawson taking charge and organising his own expedition. Mawson no longer trusted Shackleton and he confided to David that he had written to Lady Shackleton: 'to try and explain. I have stated that Sir Ernest upset some of the government officials in Australia with unwise policy. I stated finally that I myself was sad to see that Sir E. had dedicated the Geol Vol. of the 1907 expedition to Caird [the donor to his present Expedition] when Australia and Australians were the real contributors. A case of off with the old love and on with the new'.

On 13 October, David wrote to Mawson with unwelcome news. He had been inspecting a well on the Vimy Ridge when the windlass broke and he fell 80 feet to the bottom, sustaining severe internal and other injuries. Although he recovered well, the after-effects were to cause him trouble in later life. Nothing daunted, by 13 February 1917 he was once again writing of Antarctic matters, thanking Mawson for information on the progress of the AAE results—'your own scientific results seem to promise excellently'—as well as Vol. II of the Shackleton expedition geology—'good to hear that the latter is at last appearing thanks to your untiring unselfish efforts'. The volume, a compilation of individual contributions on aspects of Antarctic geology investigated by the BAE, includes one by Mawson on the petrology of rocks from the mainland of South Victoria Land (Mawson 1916).

Return to Academia

After the war, David and Mawson returned in 1919 on the same ship to Australia and to their respective Universities, but to very different futures. David was now approaching retirement while Mawson was about to resume his academic career after a very lengthy and stressful period away from the University. Little had changed during his absence: Walter Howchin was still active in the Department at the age of seventy four (although soon to retire), and facilities remained at a pre-war level. So when Mawson was appointed to the newly created position of Professor of Geology and Mineralogy in 1921, he had much work ahead of him to build what was virtually a new department. The question of adequate accommodation for teaching and research was not to be satisfactorily resolved for many years, and Mawson later regretted adopting a compromise solution which proved increasingly untenable as the years progressed. For most of the inter-war years his only full-time teaching colleague was Cecil Madigan, his Antarctic

colleague for whom he had a high regard. Unfortunately, the two were too similar in temperament and ambition for them to be able to sustain a successful personal relationship.

Inevitably most of Mawson's energies in the early 1920s were taken up with the development of his new department, and it was to be some time before he was able to pick up the threads of research. David meanwhile was beginning to relinquish some of his academic responsibilities in Sydney, and to concentrate on his long-planned work—the compilation of a 'Geology of Australia'. The success of such an ambitious project depended heavily on the cooperation of his network of fellow geologists around the continent, a network he had worked long and assiduously to develop with great success. In Adelaide, Mawson, Howchin and L.K.Ward were important members—Howchin, as we have seen, since the 1890s. Mawson had hardly settled back into academic life before he received a letter (31 May 1919) in which David expressed a hope to see him soon and talk over a letter he had received from Charles Schuchert at Yale dealing with: '... the probable Proterozoic age of everything in SA that is below the Archaeocyathae, or at any rate below the Brighton Limestone—everything, that is, that is not Archaeozoic. There is much to support this view which was our old view until the discovery of Archaeocyathinae by Howchin and myself at Normanville'. While Mawson would scarcely have had the opportunity to put his mind to South Australian geology at this time, he replied to his old teacher (although his letter has not survived) for David wrote again on 27 July expressing his keenness in joining Mawson on a trip north and interest 'that you think certain bands in the purple shales are acid tuffs, or resemble acid tuffs. In my experience red beds are often the result of the weathering of tuffs'. There is no doubt that over the next few years there were times when Mawson came to resent the regular 'pestering' on geological matters to which David subjected him. Yet David was always solicitous of Mawson's health, the concerned friend and mentor interested in his work and offering support and encouragement—as the following extracts show.

On 21 January 1920 David replied to a (lost) letter of Mawson's in which he refers to Mawson's recent illness '[the] aftermath I fear of your really appalling experiences on your Adelie Land Expedition'. He continued: 'In regard to the comparative opportunities (to which you refer in your letter) on elaborating your work on Broken Hill as compared with the scientific work of your AAE there can't be the shadow of a doubt, I think, that you chose aright, and the scientific world will be greatly the richer through your expedition. I am glad you are going to apply yourself to study of the belt between Olary and Mt. Painter. It must be a fascinating region geologically and mineralogically'. He also refers to the agreement Mawson had recently signed with the New South Wales Government, which was to take over the printing of the AAE results: 'it will be a great load off your mind when the last volume is finished and in print.' And referring to departmental matters he wrote: 'It was high time that the Geological accommodation at Adelaide was improved. I am glad your authorities recognise the need at last.'

In June 1921 David visited South Australia and with Walter Howchin made an extensive trip north through Marree and Oodnadatta to Crown Point on the Finke River (Branagan 1981). The objective was to gather information for his 'Geology of Australia' as well as for the AAAS Glacial Committee. It was a good opportunity to catch up with Mawson again, and responding to an invitation he wrote (June 5 1921): 'I have promised also to stay with Howchin and Ward, but will come to you first.' He kept in touch while on his travels, writing from Marree of the train journey from Quorn 'in the lap of luxury' having been given the use of a private rail car 'fitted with bunks, parlour compartment, cooking stove and every luxury... From Quorn we have passed over extraordinarily interesting country, both geologically and botanically.'

David travelled extensively during 1921, visiting Western Australia, Queensland and Tasmania as well as parts of the northern and western areas of South Australia to gather information for his book. Back in Sydney towards the end of the year, on 22 December, he wrote a long letter to Mawson asking for information on South Australian geology and especially on the relative ages of the granites of which there were two phases; but were both Precambrian or was one younger? And was there any evidence of intrusion into the Archaeo limestones? The questions continued.

It was during 1921 that David revived interest in the possibility that fossil remains might be present in the Precambrian rocks of the Mount Lofty Ranges, an interest which dated back to investigations with Howchin twenty five years earlier. The new 'discoveries', in siliceous limestones below the Brighton Limestone at Reynella south of Adelaide, suggested crustacean

remains and as David believed the horizon to be Upper Proterozoic (Precambrian), he was cautiously excited by the find: 'If the crustacean remains...are really, as I believe, Proterozoic in age it would be of quite extraordinary interest to secure a complete fossil specimen... There is... convenient to Adelaide, a considerable thickness of strata containing traces of obscure organisms, and it is to hoped that patient search by local geological workers will soon be rewarded...' (David 1922). David pursued the search with relentless vigour in the years ahead and was to tax the patience of Mawson at a particularly eventful period in his career.

Further Distractions

A more immediate development was precipitated at the end of 1924 by David's retirement as Professor of Geology at the University of Sydney (Branagan 1981, Corbett 1998). At the time Mawson was not fully committed to a future in South Australia despite his new responsibilities and he was keenly interested in the position, not least because of the advantages of being located in Sydney where the Government Printer had recently taken over the publication of the AAE results. He made enquiries regarding the terms of office from the Registrar in Sydney, to learn that David was strongly supporting his locum and deputy Leo Cotton. In deference to his former Professor, Mawson was slow to throw his cap in the ring. But as it transpired he almost won the chair, being the most favoured of a small group of candidates who were considered (including W. N. Benson from Otago and C. E. Tilley from Cambridge) and losing on the final vote 10–8 to Cotton. The complicated background to the appointment has been discussed by Branagan who concluded: 'There is little doubt that David swayed the Senate to ensure this appointment...[and] the Senate vote clearly was far from unanimous and some Professors were not happy with the procedures, and felt David was not as open as he might have been on the matter' (Branagan 1981: 38). Certainly to many it seemed that justice had not been done and Mawson was foremost among these, writing to David on the 23 January 1925. David replied promptly and at length justifying his role in events, and using all his charm and powers of persuasion to help pacify his aggrieved friend. He wrote (31 January, 1925):

> 'In spite of what is clear from your letter viz. that the judgment of our Senate in the matter of choice of my successor, guided as it was a good deal by myself, was in your opinion, one which did not do justice to yourself. You still sign yourself "ever yours sincerely"...Only a man of noble and generous nature could under the circumstances have done that and I know the words come from your heart. My own feeling is that nothing in the world should ever come between the friendship of you and me, and I am humbly thankful that your friendship for me has stood this tremendous test.'

He counters Mawson's queries and criticisms with his own views before conceding: 'Possibly my judgment and advice to the Senate has been at fault, but I am sure you know me well enough to be assured that if I have erred, it has not been through any motive other than a bona fide desire to do a fair thing.'

He concluded by taking the high ground and turning teacher: 'Have you tried to put yourself in Cotton's position, and imagined what you would have thought if you had run your Department at a University with conspicuous success for 6 years and then were asked to keep on for a 7th year, in order to stand down for someone else at the end of that time. Both you and I would, I think, have protested pretty vigorously—at least I know I would...we must please, agree to drop the subject. I want badly to write to you about your Antarctic matters and about S. Australian geology.'

David became concerned when Mawson did not reply to his letters and suspected that a Sydney colleague, H. S. Carslaw, Professor of Mathematics, who was also a correspondent of Mawson, had been causing trouble between them. On 17 March he wrote again: '[you have] probably been away somewhere in the Flinders Ranges and have not been getting your mail regularly' and continued 'you may have allowed the recent appointment to the Sydney Geology Chair to estrange us.' He refers to Carslaw as 'a notorious "sticky beak"' and concluded: 'If by any chance he has been making trouble between us, I would earnestly entreat you as one of my very dear friends...to tell me straight out what the trouble is.'

Two days later (19 March) David wrote again, still concerned but supporting Cotton, referring to his own disappointments (David had once, as a young man and before leaving England, sought a job in Canada), and pointing out:

> 'in your position in Adelaide, as far as research is concerned, you have one of the very choicest plums in the British Empire. What more glorious field for geological research could any one in the world have, with your special geological tastes, than the Mt. Lofty and Flinders Ranges. I can assure you, as a

> result of many years experience, that you would undoubtedly have had distinctly less opportunity for research at Sydney than you have at Adelaide.'

All this was very true but hardly likely, one would imagine, to pacify a resigned but still resentful Mawson. The letter ends on an emotional note: 'I realise that I am getting an old man now, and in the eventide of life one clings more than ever to early friends. It would be a bitter disappointment to me to lose your friendship now. I feel sure you will have the greatness and goodness to brush aside all feelings of resentment through disappointment, and will come back again into good fellowship, and will help me with my research in my old age, as you have helped me so often in the years that are gone.'

This letter drew a prompt double response from Mawson, for David wrote again on 1 April: 'Your kind letters have been an immense relief to my mind. I am most thankful that our old friendship stands firm. May it ever strengthen to one's life's end! I never perhaps fully realised what your friendship means to me until my experiences of the last four weeks. The first thing in the morning and the last thing at night you were in my thoughts and every mail I was eagerly looking for a letter from you. It was a great joy to me when it came at last.'

The Search for Ancient Fossils

David was particularly active later in 1925, travelling to Melbourne and Adelaide and on to Perth from where he intended to continue on to England. This extension of his travels was, however, postponed and he retraced his steps to Sydney. Although keen as always to see Mawson, David missed him on his way west (Mawson was in the field at Boolcoomata), while an invitation for a stopover on the return journey was declined. Nevertheless correspondence was kept up during these travels and David's letters were full of geological questions with enthusiastic references to the Cryptozoon fossils Mawson had found at Italowie and the question of their age (Mawson 1925). On 16 July, before leaving Sydney, David wrote : '[you] mention you consider the age Ordovician, is it really clear that the horizon is not Cambrian or even lower, such as the Adelaide Series?' And in response to Mawson's reply (missing) he wrote again on 9 August: '...glad to hear that you consider your Crytozoa from the Flinders Ranges at newest Cambrian, and probably Proterozoic'. He also 'hope[s] you will soon be publishing your work on the Boolcoomatta and Olary areas. It will be a very important contribution to our knowledge of Australian geology.' Later, on the train near Port Augusta on the way to Perth, he wrote again (25 August), musing on the similarity between the Italowie Cryptozoons and the algae from the Belt Series in Montana described by Walcott and adding: 'looks like strong confirmatory evidence of a Proterozoic age for the Adelaide Series.' He mentions his own finds in the believed Proterozoic rocks at Reynella and the '...hope now that you will be able to get some complete forms of those v. interesting small crustacea whose remains are so numerous, but so fragmentary in the Brighton Limestones.'

Before David left for England in late November 1925, he wrote twice to Mawson on the matter of the age of the cryptozoal limestones from Italowie, and their similarity to forms from the Macdonnell Ranges described by Ward (1925) and thought to be Ordovician in age. Very keen to clarify the matter, David wrote on 27 October: 'is for example their relation to the Adelaide Series established as by their relation to the tillites, the Brighton Limestone or the purple shale series?' Ten days later he wrote again trying to pin Mawson down on the stratigraphic position of the fossil-bearing beds.

By February 1926, David was in Cambridge writing to thank Mawson for papers received, touching on a range of matters and reviving the Cryptozoon question with a comment on the opinion of A. C. Seward (a leading palaeobotanist) which cast some doubt (later resolved) on the organic origin of the MacDonnell Ranges specimens. While David comments that his book 'progresses at a painfully slow rate', in a later letter (1 July) from London, he is again seeking Mawson's opinions, this time on Madigan's recently published work on Fleurieu Peninsula:

> 'Do you think it really proved that S. of Yankalilla – on towards Cape Jervis these limestones are really the equivalents of the Archaeocyathinae Lsts, or may they be equivalents of the Torrens etc limestones? Obviously if Madigan's views are correct, they considerably modify one's views about the dates of igneous intrusions in the Encounter Bay area. I cannot but think it probable that those pegmatised quartzites and conglomerates close to the rutile mine you showed us at Yankalilla are the basal beds of the Adelaide Series and the equivalents of the Aldgate basal beds'

David illustrated his letter with sketch sections

and was grappling from half a world away with the interpretation of one of the key areas for the elucidation of early Australian stratigraphy. He admits that his 'path is beset with doubts and difficulties, and three months ago I had a rather nasty collapse from overwork, but am better now'

Mawson meanwhile, apart from his departmental responsibilities, remained very much involved with Antarctic matters, both past and future, to the extent that his own researches and David's probing questions on matters of local geology became a secondary consideration. He was himself overseas, in South Africa and England later in 1926, and carried out a short lecture tour in the United States, the proceeds of which were to help defray the cost of publishing some of the results from the Australasian Antarctic Expedition (AAE) which were still pending. He was also beginning to formulate plans for what were to be his own last Antarctic explorations, the BANZARE voyages of 1929–31, and in 1928 was back in England seeking support and a suitable expedition ship. (He was able to lease Scott's old ship 'Discovery' from the British Government for two seasons of exploration.)

While Mawson was away and pre-occupied with Antarctic matters, David, now back in Sydney, was still strongly focused on his self-imposed task of bringing together all that was known about Australian geology, well aware of the paucity of information in many areas and equally sensitive to the fact that time was against him—a truth which only served to heighten his zeal.

The Search Intensifies

Mawson was away again overseas in 1928 and in his absence David returned to South Australia and, possibly alerted by observations made by A. R. Alderman (D. F. Branagan, pers. comm.) made further finds of (he believed) organic remains in the Precambrian rocks of the Mount Lofty Ranges. The enthusiasm with which he renewed his forays into South Australian territory was reminiscent of his discoveries with Walter Howchin around the turn of the century. Then it had been a case of a professional working with a highly competent but unqualified amateur in what was virtually a 'terra incognita'. Now thirty years on, David's actions seemed very much like an intrusion into the preserve of a small but well-established geological community, headed by a long-time colleague and friend. Not surprisingly Mawson was perturbed, and his concern was compounded by the realisation (shared by most of those who became aware of the investigations) that David had been so carried away in his enthusiasm that he had begun to lose touch with reality.

The saga began on 26 September 1928, when David wrote a very long letter to Mawson, in London at the time, telling of his discovery of fossils,which he believed to be eurypterids, in the old Beaumont quarries and also at Tea Tree Gully. The finds were 'of immense scientific importance' and he was preparing a paper for the Royal Society (David 1928). David wrote enthusiastically that 'more specimens will be of quite extraordinary palaeontological and evolutionary interest.' He also mentioned that A. R. Alderman, one of Mawson's staff, had assisted with the collecting.

Impatient that he had received no response from Mawson on the matter of the fossils, David wrote again on 9 October in a state of high excitement:

> 'To my mind the whole thing is stupendous. Some 5000 feet [1524 metres] (more or less) of strata from just above the Blue Metal Limestone down and halfway between the upper and lower Torrens Limestone contain remains of Eurypterids of great variety and in great abundance certainly on some horizons, as for example in that of the 2 ft. [60 cm] bed of quartzite at Tea Tree Gully. If only I could be with you even for a few hours I'm sure I could fill you with enthusiasm for the whole matter... It will be for you and your Geology School to enter this 'promised land'. One cannot be thankful enough that one's eyes have at last been blessed with the sight of it after some 35 years of intermittent seeking... Of course it [will] take a hundred years or more to get a fairly complete acquaintance with the Adelaide Series Fauna, but it should be quite possible in a years time to collect sufficient eurypterid material to warrant publishing a detailed description'

A Friendship Strained

Mawson while in England had heard independently of David's activities in South Australia and returning to Australia n the SS *Mooltan* he wrote on 26 September:

> 'Your letter re fossils in the Adelaide Series, near Adelaide is interesting. I have, of course, poorly indicated fossil remains from elsewhere in South Australia. Further examination of these has been held up until I can complete my section in the North Flinders Range. I got some money for expenses for this voted by the University Council late last year, and if this present matter [proposed Antarctic

expedition] had not cropped up would have been there now. The 'pellets' in the shales associated with the archaeocyathinae at Sellick's Hill, were left to you by agreement as you had first drawn attention to them. When I left Australia in March, I asked Madigan to write and ascertain whether you intended to go on with them—if not he was to examine them and the enclosing rocks for fossils... I gather from your letter and a reference made in a letter from Madigan that you examined other rock formations of the Adelaide Series and found abundant traces of life.'

'I am wondering what you are including in your operations in South Australia. I have clearly explained to you by references on several occasions both verbally and by letter, that for years past I have had a plan of campaign laid for the eventual elucidation of the stratigraphy of the older rocks of South Australia and it has been going forward according to plan. To that end I have encouraged and trained various students—and allocated to them and to Madigan problems which have been selected as part of the scheme for the ultimate complete unraveling of the stratigraphy. I have spent money in travel to see formations in South Africa and America and familiarise myself with glacial petrography and the character of the fossil forms of the plant and animal life of the oldest terraines.'

'This problem I particularly decided upon as a major life work after I found I was not wanted in Sydney for the Chair there. I am not looking for the limelight consequently have not published anything but adventitious scraps of the knowledge of the said rocks now accumulated. My plan has been to publish little until'...(here the letter ends with the remaining page(s) missing).

It was a strong letter and the tenor of it was not lost on David; but his reply on 18 October was entirely in character, beginning with an admonition of Mawson for not replying to his earlier letters and going on to feign surprise, hurt and indignation when it appears 'I have, most unintentionally, given you offense', and 'that there is a suggestion implied though not expressed in so many words, that I have been doing things behind your back, and have in some measure been jumping your claim. If any implication of this kind is intended, I wish to state most emphatically that it is most deplorable that you should entertain any such idea...'

He then embarks on a lengthy review and justification of his work in South Australia, dating from his early associations with Tate and Howchin and his publications in the Transactions of the Royal Society. He refers to the results of his Reynella discoveries (David 1922), when 'You certainly never gave one the slightest hint at the time that you in any way resented my publishing this paper'; and he reminds Mawson that the two of them collected together at Brighton and Reynella in 1925 'with the expressly affirmed object of trying to discover further and more definitive traces of life in the rocks of the Adelaide Series. Again you did not give me the least hint that you did not wish me to proceed with the work, and you most kindly and generously helped me along with the work of collecting.'

While Mawson was away earlier in the year David had concluded from his microscopic studies that the Reynella rocks 'were not only swarming with small fossil organisms, but that even their branchidae, tentacles etc. were beautifully preserved. This find greatly thrilled me and I wrote over at once to Howchin, Ward and Madigan about it and followed on myself. Had you been there of course, I would have gone to you first and no possible misunderstanding could have arisen.'

David was so carried away with enthusiasm for his discoveries and his desire to prove their authenticity that he labours the point of the frequency of his visits to Adelaide, the practical help he received from Mawson's own staff (Madigan, Alderman and Brock) as well as Howchin; and the details of the search. Perhaps part conscious of the effect this would have on Mawson he continues:

'I sincerely trust that if you have had the goodness to read this lengthy letter so far, you will realise that I was in no way prepared to find that you in the least resented your old teacher and colleague having ended his own intermittent search for fossils in the Adelaide Series by coming upon forms which for variety and structure have simply taken one's breath away... When you see one's paper in print (I hope it will be ready now in 2 or 3 weeks) I feel sure that there is nothing in the paper of which you will disapprove. One has, I hope, quoted fully and fairly your own work on the Adelaide Series in that paper. The occurrence of this fossil fauna so widely distributed throughout the Adelaide Series is a really stupendous thing teeming with possibilities, and the surface of the problem has as yet been barely scratched. It will be for you and your staff and students surely to enter into the Promised Land, and I'm sure that a grand future a really tremendous future lies before you there.' Finally he wrote:

'I am convinced that you must have written that letter to me of 29.9.28 [David has the date wrong here. He is referring to the 'Mooltan' letter of 26.9.28] under some misapprehension. Of course it is not nice for any scientist (such is human nature alas! I confess guilty to the weakness myself) to have some other scientist come along and discover a gold reef under one's front door step—personally I

FIGURE 6. Edgeworth David at the Tea Tree Gully 'fossil' site excavation, with workmen, 1930. (Photo: E. Joyce.)

don't like that sort of thing at all, and it has several times happened to me—but in your case while your feelings would be I'm sure like mine—viz. regret that one hadn't found it all out oneself—you are surely far too big a man, a world personage for all time, whose Antarctic volumes are already making a very creditable show alongside of the Challenger expedition Reports, to resent your old Professor finding after many years the bread he has cast upon the waters!'

'Your "Mooltan" letter, in the light of your non-reply to my friendly letters has caused me very much pain. It is not in the interests of our friendship or of Science. Please may I, only with the best possible intentions and friendly feeling, be allowed to return it to you? I trust...that you will kindly say yes.

Yours Very Sincerely
T. W. Edgeworth David'

This letter has been quoted at length because of the way it illuminates David's character and the nature of his relationship with Mawson. He cannot resist resorting to the ploy of one-upmanship—the old Professor scoring a point off his old student and having taken the prize, to magnanimously hand it over to his worthy pupil and successor. Although highly sensitive himself and conscious of the fact that Mawson might have been disconcerted by the news of the discoveries, he seems peculiarly insensitive in the manner of his writing. He was so overjoyed with what he believed to be the high point of his career that he could not understand others not being equally excited and responding quickly and with enthusiasm. That Mawson, whose opinion and counsel he valued so highly, did not do so was devastating and David could not hide his feelings or control his pen. Mawson could perhaps have acknowledged the flurry of letters he received more promptly, but he was very busy in London on Antarctic matters and his response, when it came in the 'Mooltan' letter, was entirely in character—courteous and cautious while expressing a sense of affront that was entirely justified.

But David was now a man obsessed, and with no further word from Mawson, he wrote again on 28 October:

'I am deeply distressed at not having any reply from you to my last three letters. You are one of my students of whom I am especially proud; and for whom I have a warm and abiding affection, which nothing can alter, and your present silence is so distressing to me just by reason of the affection I have for you. Were it not for this I would just have said "Well if he won't reply to my courteous letters written with the simple desire to remove any possible misunderstanding, why not let him rip!"

He then, mentions his indebtedness to Howchin during his recent researches, commenting: '... for with all his faults—and I wish I had as few as he—he really is a wonderful old man and has done a monumental piece of work around Adelaide and far beyond.'

On 1 November, 1928, Mawson finally put David's mind at rest writing with apologies for not replying earlier and explaining that he had been extremely busy but

'Now I am beginning to breathe again lectures are over. Alas! I am sorry to have worried you but I have merely accumulated letters from friends whose handwriting I know until the moment should arrive when I could deal with them... Yours of course are of the greatest interest. Since arriving back I have of course heard of course what your discoveries and work over here has been—and your letter of 26th September is most interesting. From reports in the English papers it was not at all clear what you had discovered. Though it did indicate that we in Adelaide had been sleeping on the most stupendous museum of clearly preserved fossils...'

(The page ends here and the remainder of the letter is missing). Courteous and cool in its introduction, the letter was beginning to warm up a little. But there was certainly no stopping David in his quest. He returned to Adelaide several times over the next few years, in 1929, 1930 and 1933, to investigate the Tea Tree Gully quarry.

Standing Firm

Mawson remained aloof and did not become seriously involved, but the fact that David was regularly assisted by members of Mawson's department, staff and students, indicates a desire to keep an eye on proceedings. David was assisted by Madigan and Alderman in 1929, by Rudd in 1930 (Fig. 6), and on his last visit in 1933 when he also visited the Beaumont Quarry, by Madigan, Kleeman and Barnes. On this, his last visit to Adelaide, he spent time with Madigan at the University looking over material from Central Australia including large masses of cryptozoa which he found 'very wonderful'. In September 1929, Mawson supported David and his collaborator, R. J. Tillyard, in seeking a grant of £100 from the Royal Society of London to open up a quarry in the Precambrian rocks near Adelaide to search for further fossils. The successful outcome enabled David to carry on his research. Mawson was asked to contribute a piece on evidence for the Precambrian age of the Adelaide Series and for an unconformity below

the fossiliferous Cambrian in the Flinders Ranges for: 'a joint paper by Tillyard, yourself and myself for the Phil. Trans., which would be a nice little "quid pro quo" for the 100 quids for which we jointly applied'. He tries again to win Mawson's enthusiasm, noting that Tillyard is '...quite definite as to the arthropod nature of the Teatree Gully fossil', a photograph and a drawing of which he includes. Mawson was not to be tempted, however, and in a cool letter (18 September 1930) he offered to run out for a couple of hours to Beaumont but 'My time, however, is extraordinarily full'. He also declines to collaborate on the proposed paper writing : 'I would not enter into a new subject without going very fully into it', while he has half a dozen papers on the verge of publication.

By the middle of 1931, with the BANZARE cruises behind him and the pressure off a little, Mawson was able to catch up with his correspondence. On 2 July he told David of Kerr-Grant's discovery of the Karoonda meteorite and the public interest aroused; most reported finds were 'myths' but one report had led to the visit by Alderman to the previously unknown Henbury meteorite craters and the collection of numerous iron meteorites. On 14 July he wrote again telling of Madigan's recent seven week trek east of Alice Springs and his discovery of archaeocyathae in the same relations to the algal limestones that Mawson himself had found in the Flinders in 1929. While David was worried by ill health and his old war injuries during 1931, he was buoyed by the publication of his geological map of Australia and by the renewed and more regular contact with his old friend. By 12 September he was optimistic enough to approach Mawson again regarding the Precambrian fossils. He wrote:

> 'Anxious that you should join me in a stratigraphical note on the horizon of those fossils in the quartzite at Teatree Gully. You remember that Tillyard and you and I joined in an application to the Royal Society London for that grant of £100. The results have exceeded even sanguine expectations, and Tillyard has prepared a very able paper on the most typical of those protoarachnoids. We have a specimen nearly perfect about 6 inches long. I should personally be extremely grateful if you would help me with this stratigraphical note. If you will say yes! I will forward at once some rough ideas of my own for you to trim up.'

Mawson did not say yes. In his reply of 23 September he quite firmly distanced himself from the Teatree Gully project:

> 'With regard to the fossil evidence you must rely on your own judgment and that of Dr Tillyard. With regard to the stratigraphical position of those beds, Howchin is, I suppose, the best authority. In view of the fact that Howchin has made a special feature of the study of the old sedimentary rocks in the neighborhood of Adelaide, I have never entered the field in any critical fashion and have reserved my efforts for more distant regions. Should Howchin pass away, I would, of course, feel it my duty to re-investigate the Adelaide region. Until then there is such a wide field in this State for further work that one feels one would do better for Geology as a whole by extending observations elsewhere rather than critically examining a field that has been given very great attention by Howchin.'

A Shift in the Relationship

David's last attempt to gain Mawson's support had failed; indeed it had merely provoked him, arousing all the old resentment about Howchin's monopoly on the geology of the Adelaide region. As far as Mawson was concerned the matter was now closed, and in his firm and calculated withdrawal from the field it seems that in the twilight of David's life, roles had been reversed: Mawson is now the mentor and David the receiver of counsel. While David continued to keep Mawson informed on the development of the Precambrian fossils saga, Mawson's letters focused on other topics including Madigan's work in the MacDonnell Ranges and Hossfeld's in the North Mount Lofty Ranges. Nevertheless David missed no opportunity to raise the question of the possibility of finding Precambrian fossils in the Flinders and Central Australia where the rocks were less altered, while he diplomatically kept away from mentioning the Adelaide fossils.

Meanwhile David had written to geologists world-wide, spreading the news of his discoveries. Mawson's skepticism regarding the Precambrian fossils was shared by many in the geological community, including J. W. Gregory (Glasgow University), C. E. Resser (Smithsonian Institution), and Calman and W. D. Lang, biologist and geologist respectively at the British Museum, and Woolnough at home. Lang was 'sorry not to be able to go as far as you in considering these supposed organisms referable to annelids or arthropods. I cannot deny that they may be organic, though even this I think rather unlikely than probable'. The general feeling was that the impressions were, as Woolnough put it, 'mere concretions'; but with Tillyard now an enthusiastic convert (as well as an expert on living

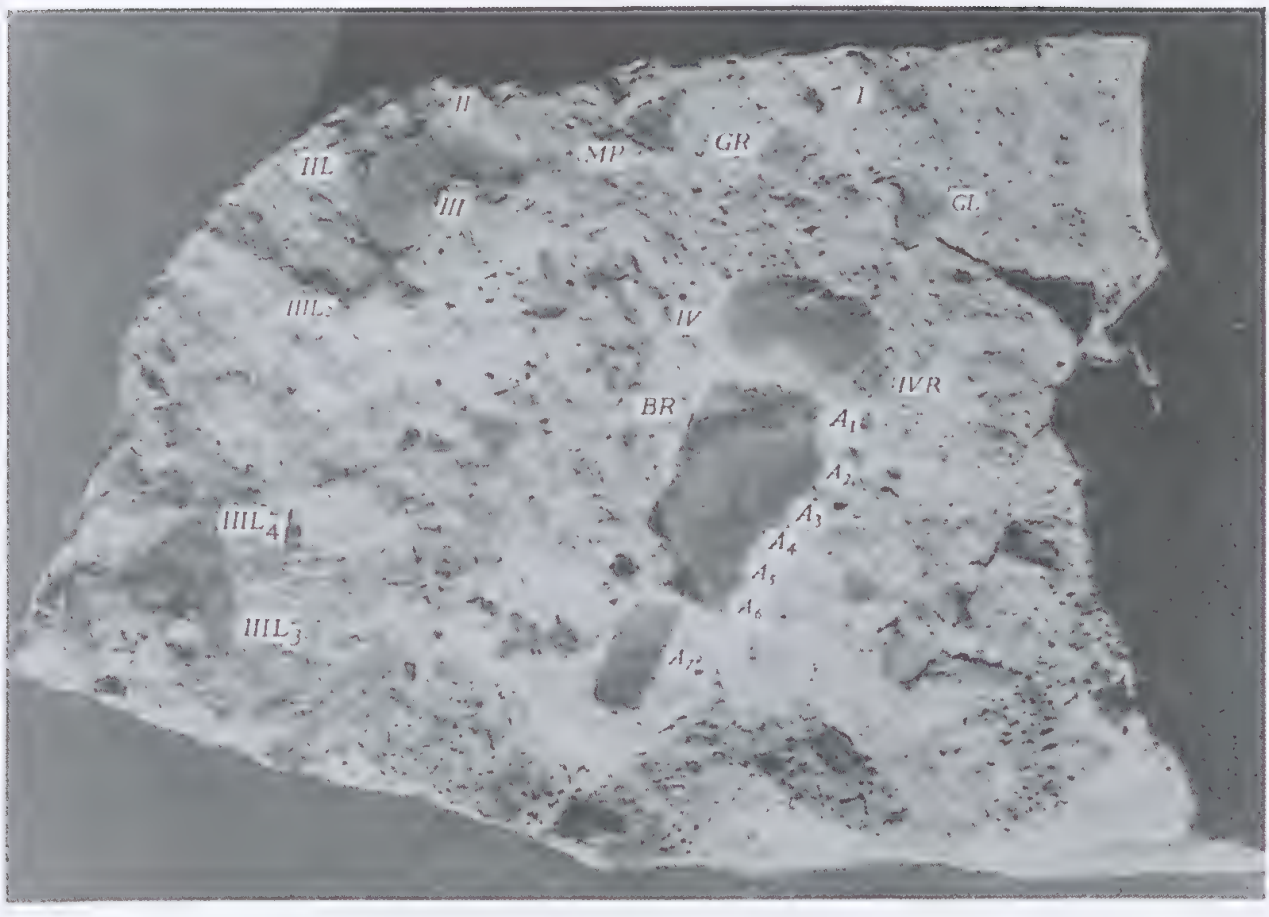


FIGURE 7. The supposed Precambrian fossil *Protadelaidea howchini*. (From David & Tillyard 1936: plate I. Angus & Robertson.)

arthropods) and cautious and non-committed support from some of his correspondents overseas, David pressed on. Tillyard remained less confident than David of gaining acceptance for their work, and sounded a warning in a letter (5 February 1932) referring to some of Calman's criticisms and continuing: 'In science, as elsewhere, nobody is to be allowed to run beyond the pre-conceived limits set by the conservative opinion of his own times. So, I much fear, you and I are in for a severe castigation when our paper comes out. Nevertheless, when we are dead, complete fossils of the same Pre-Cambrian age will be brought to light, and will to a large extent justify the reconstruction which we have given'

The paper referred to was rejected by the Royal Society of London in July 1932. Tillyard meanwhile, in a letter of 7 September 1932, was concerned about the fate of specimens sent over to the British Museum in the light of the rejection of the paper by the Royal Society. While the Society would 'return the typescript and the drawings..., these are of little value without the type fossils'. He was also concerned about Mawson, and wrote: 'I am very sanguine as to Mawson's reaction; do not forget the old complex about your working in his field. He is a very nice fellow and is always very decent to me, but I wonder whether he has a big enough mind to see your point of view in this particular case.' Tillyard was also keen that another application be made for a research grant from the Royal Society. Mawson had been an influential supporter who had helped secure the initial grant, but this time Tillyard is less than confident, writing: 'As he [Mawson] is going to London next month, I should expect that he would be more inclined to secure a grant for exploration in the Flinders or MacDonnell Ranges.' Ten days later Tillyard was able to report that the specimens were to be returned and the scientific fraternity were a little less antagonistic. 'Perhaps they now feel rather ashamed of having turned us down, and are trying to make amends'. Tillyard, still hopeful of enlisting Mawson's support, wrote to David (22 October 1932) 'I do hope you will bring Mawson round to our way of thinking'

David was still trying. On 2 September he had written to Mawson with the Royal Society paper rejection fresh in his mind and sending copies of the referees' reports (by Calman and Lang of the British Museum) with his own critical asides. He

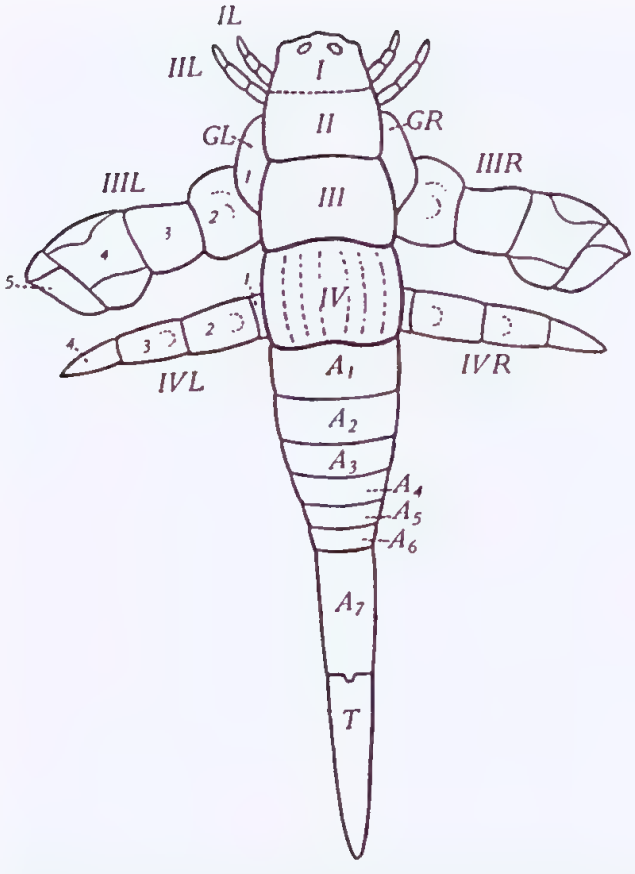


FIGURE 8. Reconstruction of *Protadelaidea howchini*, dorsal view. (From David & Tillyard 1936: plate IX. Angus & Robertson.)

clearly did not accept the judges verdict and had found some of the comments offensive. Calman, 'a mere zoologist' had concluded his report : 'with great reluctance I have come to the conclusion that from a zoological point of view this paper is entirely without scientific value.' Lang's criticisms, 'though not rude like Calman's... [are] not brought forward at all... if only he had read our paper carefully... His criticisms really in no way weaken our position.' David then appealed to Mawson: 'Unwilling as I am to trespass on your time, which I know is so very fully occupied, I wish you to kindly do me the favour of reading through these notes on the Adelaide fossils very carefully, if you will be so good. With the arthritis becoming constantly more acute... one realises alas! that that little bit of work at Teatree Gully may be the last bit of field work of one's lifetime and which embodies the only discovery of any consequence that I have ever made, I am naturally anxious to see a reasonably good foundation laid.'

On 6 September he wrote again with further descriptions of the fossils and concluded '...in our opinion, the evidence for the organic origin of these fossils is so conclusive as to be quite overwhelming.' A postscript hammered home the point:

> 'The Teatree Gully quartzite has already yielded so many remarkable and entirely new forms of pre-Cambrian animal life that in my opinion its further exploitation in the way of quarrying and splitting the blocks parallel to the cleavage is really of enormous palaeontological importance. No other strata of such an age anywhere in the world, have yielded results in the least comparable with this. Surely before trying out new areas in the northern Flinders or the Macdonnells further work should be done at Teatree Gully e.g. the discovery of a third specimen of Protadelaidea howchini [Figs 7–8] would surely satisfy even the British Museum brahmans...'

On the 15 September he wrote advocating further quarrying at Teatree Gully, adding 'I would immensely like to hobble over the ground (while I can still hobble) in your company some time before you leave for England.' Included in this letter is an annotated section from his own paper (David 1928), indicating the position of the supposed fossil bearing-beds (Fig. 9).

Mawson never made that visit with David, for he left for England towards the end of 1932 and did not return until July 1933. Before leaving however, he forwarded to the Royal Society in London, at David's request, an application for a further grant for the excavation of the fossil site. Despite David's continuing hope for unqualified support, Mawson's attitude was at once diplomatic, uncompromising, yet supportive. He appended the following statement: '[as the] wording on the document does not properly express my views, I am merely forwarding this supporting note... The position is that Sir Edgeworth David is still convinced that certain markings, impressions and cavities in a thin bed...of ?middle Proterozoic age are of organic origin. My view is that some of them are difficult to account [for] on a purely inorganic basis, but I see nothing indisputably organic in them'. His conclusion was pure diplomacy. 'If they are organic their occurrence is of great importance.' He supports the further grant to prove or disprove the "fossils" and would like to see the matter further investigated.

Disappointed to learn that Mawson had not approved of the wording of the Royal Society application (he claimed he thought that Mawson had accepted *Protadelaidea*), but still undaunted, he returned to South Australia in April 1933, while Mawson was away, on what was to be his last visit. On this occasion he was assisted by Madigan, Kleeman and Barnes in the field and stayed at Mawson's home.

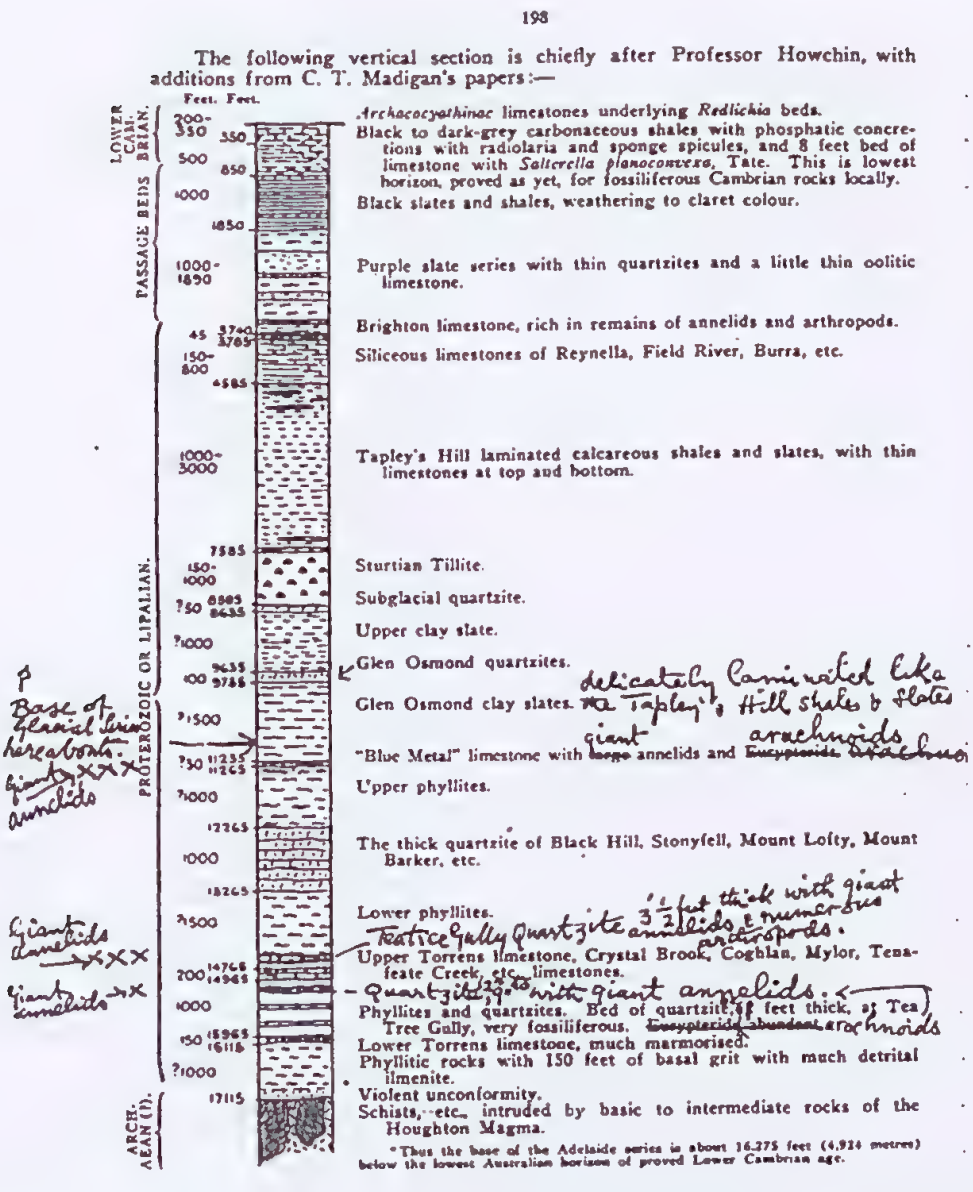

198
The following vertical section is chiefly after Professor Howchin, with additions from C. T. Madigan's papers:—
Feet. Feet.
LOWER CAMBRIAN.
PASSAGE BEDS
PROTEROZOIC OR LIPALIAN.
ARCHAEAN (?).
Archaeocyathinae limestones underlying Redlichia beds.
Black to dark-grey carbonaceous shales with phosphatic concretions with radiolaria and sponge spicules, and 8 feet bed of limestone with Salterella planoconvexa, Tate. This is lowest horizon, proved as yet, for fossiliferous Cambrian rocks locally.
Black slates and shales, weathering to claret colour.
Purple slate series with thin quartzites and a little thin oolitic limestone.
Brighton limestone, rich in remains of annelids and arthropods.
Siliceous limestones of Reynella, Field River, Burra, etc.
Tapley's Hill laminated calcareous shales and slates, with thin limestones at top and bottom.
Sturtian Tillite.
Subglacial quartzite.
Upper clay slate.
Glen Osmond quartzites.
Glen Osmond clay slates.
"Blue Metal" limestone with large annelids and Eurypterids. Arachnoids
Upper phyllites.
The thick quartzite of Black Hill, Stonyfell, Mount Lofty, Mount Barker, etc.
Lower phyllites.
Upper Torrens limestone, Crystal Brook, Coghlan, Mylor, Teneafeate Creek, etc., limestones.
Phyllites and quartzites. Bed of quartzite, 3 feet thick, at Tea Tree Gully, very fossiliferous. Eurypterids abundant. Arachnoids
Lower Torrens limestone, much marmorised.
Phyllitic rocks with 150 feet of basal grit with much detrital ilmenite.
Violent unconformity.
Schists, etc., intruded by basic to intermediate rocks of the Houghton Magma.
* Thus the base of the Adelaide series is about 16,275 feet (4,924 metres) below the lowest Australian horizon of proved Lower Cambrian age.
delicately carnivalled like Tapley's Hill shales & slates
giant arachnoids
Base of Glacial Series hereabouts.
giant annelids
Giant annelids
Giant annelids
Beltrice Gully Quartzite 3½ feet thick with giant annelids & numerous arthropods.
Quartzite, 3 ft. with giant annelids.

FIGURE 9. Annotated geological section (from David 1928), showing position of supposed fossil-bearing formations in the Precambrian Adelaide Series. This was included in a letter from David to Mawson, 15 September, 1932.

Envoi

By the end of 1933, David's health was giving serious cause for concern but his letters to Mawson on a range of geological matters continued unabated. He wrote in December 1933: 'My health has been v. poor lately and my suffering from my old war injuries has been increasing but I am thankful to say that there is some "life in the old dog yet" and I may yet live to be of some service to my very distinguished old student for whom I cherish no small affection.' In March 1934 he was writing of Antarctic matters, Mawson's work on coorongite in the South East and north Flinders Ranges geology. He also had plans to visit his publisher Edward Arnold in England for discussions on the still uncompleted 'Geology of Australia'. Meanwhile work on the book was continuing, though very slowly, with the help of W. R. Browne and other Sydney University geologists. By July the trip to England had been deferred to the end of the year. In a letter of reply to one of Mawson dealing with glacial matters on July 11, his old student was asked about his two Precambrian glaciations with the question: 'Have you, please, published anything about this?', while his last letter to Mawson (15 August 1934) was concerned with the Henbury meteorite crater reserve.

David did not live to complete his book. He died in Sydney on 28 August 1934 and W. R. Browne eventually saw it through to publication. This proved a monumental assignment as David had been continually re-organising his material

and the book lacked a final plan. Also as the project had been in progress for so long, not the least of Browne's tasks was to bring the information up to date. 'The Geology of the Commonwealth of Australia' in three volumes was published by Edward Arnold in 1950, edited and much supplemented by Browne. As Branagan has written: 'Browne had to write David's "Geology"—and he did it magnificently' (Branagan 1981: 52).

Lady David began compiling a biography of Sir Edgeworth after his death but her draft had been rejected by Angus and Robertson. This was a severe blow, and her daughter now set about rewriting the manuscript before taking it off to seek a publisher. She wrote to Mawson on 27 March 1936: 'I have put in 18 months severe work and amassed facts only about him—but he had such a romantic life it is not easy for me to "see the wood for the trees".' She concluded: 'I am so glad you loved him.'

Mawson felt the loss of his old professor keenly and when asked by the Royal Society of London to write an obituary he did so in prose that was very high in its praise, not only of David's scientific achievements, but of his character and personality. He wrote :

> 'Attributes of his greatness were an endearing charm of manner and a nobility of mind embodying high Christian principles. He was an accomplished scholar plentifully endowed with fine instinct and broad vision... With a rare fund of anecdote and a keen sense of humour, as well as a vivid dramatic appeal and exceptional powers of narration, he was always good company and the centre of attraction in any gathering. By tact, influence, and a unique personality, he promoted science, and especially geological research, in Australia, for more than four decades.'

And with reference to David's geological achievements: 'Next in interest to the investigation of evidences of past glacial climates in the Australian geological record, the subject which claimed David's special attention during the later years of his life, was that of search for fossil evidences for life in the Pre-Cambrian terrains of the neighborhood of Adelaide. In what appears to be the upper limit of the local Pre-Cambrian sediments, he, some years ago, recorded impressions of a fragmentary nature which he determined as relics of crustacean life. He more recently came upon coarser and still more obscure impressions at a much lower horizon; these, also, he believed to be fragments of crustacean or proto-crustacean life...he was still investigating this fascinating problem at the time of his death.' (Mawson 1935).

The abundant material that David had left on the supposed fossils, was, at Lady David's request, organised by W. R. Browne and Leo Cotton and, in cooperation with Tillyard, published in book form by Angus and Robertson (David & Tillyard 1936).

Precambrian Fossils – the Sequel

With David no longer there to practise his persuasive advocacy for the Precambrian fossils, the memoir did nothing to revive interest and there were few geologists in the years ahead who were prepared to keep an open mind on the subject. Fifty years on, S. Warren Carey, who had seen some of the original specimens, was a powerful spokesperson for the skeptics. He wrote: 'I don't know any palaeontologist today who accepts them as organic remains, and little is said about them, as though this skeleton in David's cupboard is best forgotten' (Carey 1990: 46). But over the years between they had not been entirely forgotten. Even if David was wrong, palaeontologists since his day have recognised that the relatively complex animals found as fossils in the earliest Palaeozoic rocks must have had Precambrian ancestors. In the mid-1950s, a highly respected textbook of invertebrate palaeontology made the point clearly: 'The Phylum Arthropoda comprises an unusually large and varied group of highly developed invertebrates whose clearly long and extensive history reaches back almost certainly into the Pre-Cambrian' (Shrock and Twenhofel 1953: 536), and although they do not discuss David's discoveries, his Memoir is listed in their bibliography.

If David's fossils were indeed 'mere concretions', how could such an accomplished scientist (and his specialist collaborator) have made such a misinterpretation? Carey asks the question and proffers a possible answer; perhaps: 'David, working through so many thousands of specimens, may have progressively filtered out those with bilateral symmetry, and Tillyard, working with such a biased set, could easily have been convinced that they had to be organic' (Carey 1990: 46).

On home ground in South Australia, David's torch had been kept burning since the late 1930s when a young geologist appeared, who carried many of David's characteristics, notably enthusiasm, flair and imagination. R. C. (Reg) Sprigg stood in the same relationship to Mawson as Mawson had to David four decades earlier. As a student he found what he thought were

arthropod remains in rocks close to the Precambrian–Cambrian boundary at Sellicks Hill south of Adelaide. Mawson was singularly unimpressed and later, much to Sprigg's chagrin, had the key specimen thrown away (Sprigg 1989: 95). But within a few years serendipity took a hand, and Sprigg, working for the South Australian Department of Mines on a field mapping project in the Ediacara Hills west of the main Flinders Ranges, found a fossil jellyfish in rocks at that time believed to be lowermost Cambrian. Mawson, perhaps inevitably, was not initially convinced, and there was a strong skeptical element in the geological fraternity regarding the validity of Sprigg's discovery. However, further finds by Sprigg and other collectors, of more jellyfish as well as numerous other undoubtedly animal fossils, with a wide range of forms and some with problematical affinities, became world famous as the Ediacara Fauna—the earliest animal fossils known in the geological record. In his final years Mawson was a strong supporter of the investigation of the Ediacara fossils and on-going research was carried out in his old department after his death by Martin Glaessner and Mary Wade.

Mawson's vision of unravelling and ordering the Precambrian rocks of the Flinders Ranges had been largely realised but success in finding fossils (other than stromatolites), which he felt must lie in the thick sedimentary sequence, had eluded him. While David's (as he believed) misguided forays into the Adelaide region had annoyed him, the success of one of his own students in finding the earliest fossil animals was a vindication of his own long dedication to teaching and researching in the northern ranges, as well as being a fitting justification of David's equally dedicated search for evidence of life in the distant past. More recent finds of problematica similar to David's in North America have revived interest in the nature of these supposed 'fossils', with an indication that there may be an organic component in some of them.

Postscript

David's death was a significant event in the development of Australian geology. It also came at a time which marked a watershed in the life and career of Douglas Mawson. At the age of fifty-two his direct involvement with Antarctic exploration had ended and he began his most sustained period of research into South Australian geology. Between 1935 and 1952 (the year he retired), Mawson published 30 significant papers, over half of them concerned with the Precambrian rocks of the Flinders Ranges. (This compares with a similar number of papers over a period twice as long between 1904 and 1934 on a wide variety of topics). The death of Walter Howchin in 1937, three years after David, saw the approach of the end of the old order of Australian geologists, and in South Australia, as elsewhere in Australia, a new generation of native-born and trained geologists had emerged, all of them graduates of Mawson's department and including, in addition to R. C. Sprigg, many others, notably E. A. Rudd, L. W. Parkin, Paul Hossfeld and A. Kleeman. Many of Mawson's later papers were co-authored with junior members of his department or former students.

The lives of T. W. Edgeworth David and Douglas Mawson spanned the years when geology became established as a profession in Australia. David was the pioneer in the professionalising of the science, his department at Sydney, in the early years of the century, producing a galaxy of talented men and women from which Mawson was to emerge as the shining star, not least because of his international reputation as an Antarctic explorer. David was also the first, and highly successful, networker in Australian geology and Mawson, a generation later, by establishing his own equally effective department, extended the net and through his effort and inspiration, created an influence which is still potent at the close of the twentieth century.

Acknowledgments

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References

BRANAGAN, D. F. (ed.) 1973. 'Rocks, Fossils, Profs: Geological Sciences in the University of Sydney 1866–1973'. Science Press, Sydney. 184 pp.

BRANAGAN, D. F. 1981. Putting geology on the map. *Historical Records of Australian Science.* **5**(2): 31–57.

BRANAGAN, D. F. 1985. Earthy Sciences *in* 'Ever Reaping Something New—A Science Centenary'. Ed. D. Branagan & G. Holland. The University of Sydney, Sydney.

CAREY, S. W. 1990. 'Sir Edgeworth David Memorial Oration: "Knight Errant of Science".' Australasian Institute of Mining and Metallurgy. Parkville, Victoria. xiv, 74 pp.

CORBETT, D. W. 1998. Douglas Mawson: the geologist as explorer. *Records of the South Australian Museum.* **30**(2): 107–136.

DAVID, T. W. E. 1897. Evidence of glacial action in the Carboniferous and Hawkesbury Series, New South Wales. *Quarterly Journal of the Geological Society of London* **43**: 190–196.

DAVID, T. W. E. & W. HOWCHIN. 1897. Notes on the glacial features of Inman Valley, Yankalilla and Cape Jervis districts. *Transactions of the Royal Society of South Australia.* **21**: 61–67.

DAVID, T. W. E. (with R. HELMS & E. F. PITTMAN) 1901. Geological notes on Kosciusko, with special reference to evidence of glacial action. *Proceedings of the Linnean Society of New South Wales* **26**: 26–74.

DAVID, T. W. E. & R. PRIESTLEY, 1914. Geology Vol. I. Reports on the scientific investigations, the British Antarctic Expedition, 1907–08.

DAVID, T. W. E. 1922. Occurrence of remains of small crustacea in the Proterozoic? or Lower Cambrian? rocks of Reynella near Adelaide. *Transactions of the Royal Society of South Australia.* **46**; 6–8.

DAVID, T. W. E. 1928. Notes on the newly-discovered fossils in the Adelaide Series (Lipalian?), South Australia. *Transactions of the Royal Society of South Australia.* **52**: 191–209.

DAVID, T. W. E. 1932. 'Explanatory notes to accompany a new geological map of the Commonwealth of Australia'. Australasian Medical Publishing Company, Sydney.

DAVID, T. W. E. & R. J. TILLYARD. 1936. 'Memoir on fossils of the late Pre-Cambrian (Newer Proterozoic) from the Adelaide Series, South Australia'. Angus and Robertson, Sydney. 122 pp, pls I–XIII.

DAVID, T. W. E. 1950. 'The Geology of the Commonwealth of Australia (edited and much supplemented by W. R. BROWNE)'. 3 vols. Edward Arnold, London.

HOWCHIN, W. 1897. On the occurrence of Lower Cambrian fossils in the Mount Lofty Ranges. *Transactions of the Royal Society of South Australia.* **20**(2): 74–86.

HOWCHIN, W. 1901. Preliminary note on the existence of glacial beds of Cambrian age in South Australia. *Transactions of the Royal Society of South Australia.* **25**: 10–13.

INNES, M. & H. DUFF. 1990. 'Mawson's Papers'. The Mawson Institute for Antarctic Research, The University of Adelaide.

JACKA, F. & E. JACKA. (Eds.). 1991. 'Mawson's Antarctic Diaries'. Allen & Unwin, Sydney.

MACLEOD, R. 1988. 'Full of Honour and Gain to Science': Munitions Production, Technical Intelligence and the Wartime Career of Sir Douglas Mawson, F.R.S. *Historical Records of Australian Science.* **7**(2): 189–204.

MAWSON, D. & T. H. LABY. 1904. Preliminary observations on radioactivity and the occurrence of radium in Australian minerals. *Journal and Proceedings of the Royal Society of New South Wales.* **38**: 382–389.

MAWSON, D. 1905. The geology of the New Hebrides. *Proceedings of the Linnean Society of New South Wales.* **3**: 400–485.

MAWSON, D. 1906. On certain new mineral species associated with carnotite in the radioactive orebody Olary. *Transactions of the Royal Society of South Australia.* **30**: 188–193.

MAWSON, D. 1912. Geological investigations in the Broken Hill area. *Memoir of the Royal Society of South Australia.* **2**(4): 211–319.

MAWSON, D. 1916. Petrology of rock collections from the mainland of south Victoria Land. Reports of the British Antarctic Expedition, 1907–09, *Geology.* **2**: 201–237.

MAWSON, D. 1925. Evidence and indications of algal contributions in the Cambrian and Pre-Cambrian limestones of South Australia. *Transactions of the Royal Society of South Australia.* **49**: 186–190.

MAWSON, D. 1935. Sir Tannatt William Edgeworth David 1858–1934. Obituary notices of the *Royal Society of London.* **4**: 493–501.

SHROCK, R. R. & W. H. TWENHOFEL. 1953. 'Principles of Invertebrate Paleontology'. McGraw Hill, New York.

SPRIGG, R. C. 1989. 'Geology is Fun'. Published by the author, Adelaide.

WALCOTT, C. D. 1914. Pre-Cambrian Algonkian algal flora. *Smithsonian Miscellaneous Collections.* **64**(2): 77–118.

WARD, L. K. 1925. Notes on the geological structure of Central Australia. *Transactions of the Royal Society of South Australia.* **49**: 61–84.

The David–Mawson correspondence quoted in this paper is to be found in the Mawson Papers housed in the Urrbrae House Historic Precinct, Waite Campus, The University of Adelaide. It is catalogued under Control Number 24 DM, Inventory Number 4 (see Innes and Duff 1990 pp. 5/8,5/9.)

The Mawson-David correspondence is housed in the David archive at the Fisher Library, The University of Sydney.

NOTE ON THE ORIGIN OF FRESHWATER CRAYFISH OCCURRING ON KANGAROO ISLAND, SOUTH AUSTRALIA

Two species of freshwater crayfish occur on Kangaroo Island. The common yabbie *Cherax destructor* Clark, 1936 and the marron, *Cherax tenuimanus* (Smith, 1912).

The marron, a riverine species native to south Western Australia, is an obvious introduction. Marron are highly desirable as an aquaculture species (Morrissy 1984) and were introduced to Queensland and northern New South Wales in 1979 (Austin 1985). They were introduced to Kangaroo Island, for aquaculture, in the early 1980s but soon escaped and by the mid 1980s became established in the nearby Ravine des Casoars. Marron have since spread, or have been translocated, so that they are now also well established in Rocky River and the De Mole River with some patchy occurrences in Middle River and Cygnet River (Nicholls 1995) and probably also occur in other permanent water on the Island.

The origin of *Cherax destructor* is more difficult to determine. In 1979 and 1981 I conducted extensive surveys of Kangaroo Island in order to determine the presence of freshwater crayfish and to sample for other freshwater invertebrates. I found populations of *Cherax destructor* in most freshwater streams on the eastern half of the Island, extending as far west as the upper reaches of the South-West River (Zeidler 1982). Although I did not take quantitative samples at the time I noted that *C. destructor* was less abundant as I travelled west of Cygnet River suggesting that the species was spreading west or had reached some geographical barrier at the South-West River. There seemed no reason for its absence in apparently suitable habitats in the Flinders Chase region. At the time I assumed that the Kangaroo Island population of *C. destructor* had been introduced or had become isolated when the Island separated from the mainland. The species is relatively common on the Fleurieu Peninsula.

Campbell *et al.* (1994) who conducted genetic studies of *Cherax destructor* and *C. albidus* from South Australia and western Victoria, also examined a Kangaroo Island population from Stunsail Boom River. They found that the Kangaroo Island population lacked the genetic divergence characteristic of most of the mainland populations. A lack of genetic divergence is typical of introduced populations and they concluded that the crayfish populating Kangaroo Island are not endemic but have been introduced.

Recently I came across some old correspondence, addressed to Herbert Hale, dated 27 Feb. 1946 which states that some 20 years previous yabbies were introduced to 'Cygnet River about one mile up from the bridge on the Kingscote-Hog Bay main road' from 'the Torrens at West Marden'. The same correspondence states that more specimens were introduced to Cygnet River in about 1938 and that some were also put in the Middle River.

Despite the introduction of yabbies to Cygnet River in about 1926 none were caught almost 20 years later ('we have tried in the Cygnet River on several occasions, to see if we could catch yabbies, but have not had any luck') indicating that the yabbies had difficulty becoming established. The fact that yabbies are now abundant in Cygnet River, and are easily caught, suggests that they were not present prior to the above mentioned introduction. Their spread west seems to have been a slow process.

In 1986 I received a number of specimens of both *C. tenuimanus* and *C. destructor* caught in the Ravine des Casoars from the park ranger at Flinders Chase, Mr Terry Dennis. This was quite alarming because apart from confirming the establishment of the marron in this once crayfish-free environment, it also confirmed that the common yabbie, *Cherax destructor*, had also been introduced as both were absent in 1981. Judging by the topography of Flinders Chase and the apparent slow rate at which *C. destructor* became established in the eastern part of the Island a deliberate introduction to Flinders Chase of this species seems the only logical conclusion.

Without a base-line knowledge of the freshwater fauna of Kangaroo Island prior to the introduction of freshwater crayfish it is impossible to ascertain the ecological implications of such introductions. It is interesting to note that *C. destructor*, a very successful and invasive species, had difficulty in becoming established in Cygnet River.

Despite local knowledge of the existence of freshwater crayfish on Kangaroo Island since about 1926 the only record in the literature up until 1982 (Zeidler 1982) was that of Riek (1969) who reported a species of *Geocharax* from Kangaroo Island. Unfortunately he gave no precise locality data and the record seemed

dubious. A search of collections in all Australian museums failed to confirm the presence of this genus on the Island (Gross *et al.* 1979) and no specimens, or evidence (remains) of this genus were found during my surveys of 1979 and 1981. I am thus reasonably confident that Riek's record is erroneous. Most likely it was based on a specimen labelled 'KI' referring to King Island, Bass Strait, which is a known habitat for species of this genus.

References

AUSTIN, C. M. 1985. Introduction of the yabbie, *Cherax destructor* (Decapoda: Parastacidae) into Southwestern Australia. *Western Australian Naturalist* **16**: 78–82.

CAMPBELL, N. J. H., GEDDES, M. C. & ADAMS, M. 1994. Genetic variation in the yabbies, *Cherax destructor* and *C. albidus* (Crustacea: Decapoda: Parastacidae), indicates the presence of a single, highly sub-structured species. *Australian Journal of Zoology* **42**: 745–760.

CLARK, E. 1936. The freshwater and land crayfishes of Australia. *Memoirs of the National Museum* **10**: 5–58, pls 1–11.

GROSS, G. F., LEE D. C. & ZEIDLER, W. 1979. Invertebrates. Pp. 129–137 *in* 'Natural History of Kangaroo Island'. Ed. M. J. Tyler, C. R. Twidale and J. K. Ling. Royal Society of South Australia: Adelaide.

MORRISSY, N. M. 1984. Crayfish research and industry activities in Australia. *Freshwater Crayfish* **5**: 534–544.

NICHOLLS, S. 1995. Factors affecting temnocephalid distribution and abundance on Kangaroo Island. Unpublished Honours Thesis, Department of Environmental Biology, University of Adelaide.

RIEK, E. F. 1969. The Australian freshwater crayfish (Crustacea: Decapoda: Parastacidae), with descriptions of new species. *Australian Journal of Zoology* **17**: 855–918.

SMITH, G. 1912. The freshwater crayfishes of Australia. *Proceedings of the Zoological Society of London* **10**: 144–171, pls 14–27.

ZEIDLER, W. 1982. South Australian freshwater crayfish. *South Australian Naturalist* **56**: 36–42.

Wolfgang ZEIDLER, South Australian Museum, North Terrace, Adelaide, 5000. *Records of the South Australian Museum* **33**(1): 71–72, 2000.

FIRST RECORD OF THE MARINE TARDIGRADE GENUS *BATILLIPES* (ARTHROTARDIGRADA: BATILLIPEDIDAE) FROM SOUTH AUSTRALIA WITH A DESCRIPTION OF A NEW SPECIES

R. M. KRISTENSEN AND B. S. MACKNESS

MUSEUM VICTORIA 16 NOV 2000

DEDICATION: To the late Alan Bird who provided the first illuminating studies on South Australian tardigrades.

KRISTENSEN, R. M. & MACKNESS, B. S. 2000. First record of the marine tardigrade genus *Batillipes* (Arthrotardigrada: Batillipedidae) from South Australia with a description of a new species. *Records of the South Australian Museum* 33(2): 73–87.

A new species of marine tardigrade, *Batillipes lesteri* sp. nov. is described from beach sand collected at below low tide at Henley Beach, Adelaide, South Australia. Eighteen specimens including both sexes, four-toed larvae and juveniles were recovered. The new species differs from all other members of the Batillipedidae by its combination of toe patterns, fourth lateral projections and caudal apparatus. It is the first member of the genus to be described from South Australia and only the third species to be recorded from the Southern Hemisphere.

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The interstitial heterotardigrade genus *Batillipes* was first described by Richters (1909) based on specimens of *B. mirus* from Kieler Bay, in the Baltic Sea. Eight years later, Hay (1917) described *B. caudatus* obtained from algae from jetties at Beaufort, North Carolina. This American species was later incorrectly synonymised by Marcus (1929) with *B. mirus*. Marcus (1946) described a third species, *B. pennaki* from the Atlantic coasts of North and South America. Since that time many more new species have been discovered and named: *B. similis* Schulz, 1955; *B. carnonensis* Fize, 1957; *B. littoralis, B. phreaticus* Renaud-Debyser, 1959; *B. friaufi* Riggin, 1962; *B. annulatus,* De Zio 1962; *B. bullacaudatus* McGinty and Higgins, 1968; *B. gilmartini* McGinty, 1969; *B. dicrocercus* Pollock, 1970; *B. acaudatus, B.tubernatis* Pollock, 1971; *B. noerrevangi, B. roscoffensis* Kristensen, 1978; *B. adriaticus* Grimaldi de Zio *et al.*, 1979; *B. africanus, B. marcelli* Morone De Lucia *et al.*, 1988; *B. tridentatus* Pollock, 1989; *B. crassipes* Tchesunov and Mokievsky, 1995; *B. philippinensis, B. longispinosus* and *B. orientalis* Chang and Rho, 1997a,b. Most recently, Rho *et al.* 1999 described a new species *B. rotundiculus* and provided a key to eight batillipedid tardigrades from Korea.

Mackness (1999) recorded the first Australian members of *Batillipes* from beaches in Victoria but was unable to identify the animals to species level due to poor preservation. This paper presents the first record of the genus from South Australia and describes a new species based on 18 specimens collected subtidally from a beach in South Australia. Furthermore, the paper describes its life cycle including the four-toed larva, juveniles, young adults as well as their sexual dimorphism.

MATERIALS AND METHODS

Two sand samples (2 x 750 ml approx.) were collected on 6 November, 1995 by one of us (BM) at Henley Beach, Adelaide, South Australia (34° 55'S, 138° 30'E). One sample (A1) was taken at the low tide level and the other (A2), was taken at one metre water depth (subtidal). Tardigrades were only obtained from the subtidal sample. The tardigrades were sorted out alive at the Queensland Museum by RMK, two days after they were received. Each sample was fresh-water 'shocked' following the procedure set out by Kristensen and Higgins (1984). This involved soaking the sediments in fresh water for about 20

seconds and then swirling them around. This osmotically incapacitated the tardigrades which were collected after the heavier material had settled by decanting off the liquid through a 63 µm mesh filter. The meiofauna was sorted using a binocular microscope (40–80 x magnifications) and then examined using phase contrast microscopes (1000 x magnifications). A few tardigrades were removed and placed in sea water where they quickly recovered. All drawings were made using camera-lucida techniques on live animals. The reason for using live material for illustrations is that the lipoid eyes and the hard structures in the pharyngeal disappear in all known permanent mounts.

Live tardigrades adhering with their suction discs to the cover glass were then preserved in 2% buffered formalin added under the cover glass. Permanent mounts were made by adding specimens to a glycerine solution (4%) under cover glasses. After two days dehydration, the cover glasses were ringed with Glyceel. Measurements were only made on permanent mounts and taken to the nearest micron using an ocular micrometer. Comparisons were made with reference collections held in the Zoological Museum of the University of Copenhagen (ZMUC) and with original type descriptions from the literature. Measurements for 12 specimens are provided in Tables 1–3.

Systematics

Order Arthrotardigrada Marcus, 1927

Family BATILLIPEDIDAE Ramazzotti, 1962

Revised family diagnosis

Arthrotardigrade with large median cirrus present and secondary clava dome-shaped. Lateral cirrus and primary clava with a common pedestal. Internal cirrus and median cirrus with well-developed cirrophorus, external cirrus with indistinct cirrophorus. All cephalic cirri without scapus and flagellum. With four toes (in larvae) or six toes (in adults) of different lengths, with adhesive or suction disc at terminus of toe stalk. Claws absent. Cuticular seminal receptacles absent.

Discussion

This family had originally included the genera *Batillipes* and *Orzeliscus* Marcus. In this paper the family Orzeliscidae is considered as a sister group of the family Halechiniscidae and not the Batillipedidae. The Batillipidedae is therefore currently regarded as generically monotypic.

Batillipes Richters, 1909

Generic diagnosis

As Batillipedidae is monogeneric, the generic diagnosis is the same as that for the family.

Type species: Batillipes mirus Richters, 1909 by monotypy.

Type locality: Kieler Bay, Baltic Sea.

Discussion

The original description of *B. mirus* was written in German and perhaps this is the reason that this excellent early description has been overlooked. *Batillipes mirus* is a very large arthrotardigrade up to 720 µm (mean = 400–600 µm) with spade-shaped suction discs, similar to those of *B. tubernatis* illustrated by McKirdy (1975). The type material of *B. mirus* was collected subtidally (20 m water depth) and not in sandy beaches as nearly all later records for *B. mirus* worldwide. In the comprehensive review by McKirdy (1975) of the genus *Batillipes*, six species were examined carefully. The American '*B. mirus*' is a middle-sized batillipedid (about 160 µm) with ovoid or round suction discs. It is very clear that these animals are not the same as the type species. It may well be that all tidal animals called '*B. mirus*' are in fact *B. caudatus* described by Hay (1917) from North Carolina. This species was later incorrectly synonymised by Marcus (1929) with *B. mirus*. The cosmopolitan distribution (Table 4) of *B. mirus* must therefore be considered doubtful and new, worldwide samplings are necessary.

Batillipes lesteri n. sp.

(Figs 1–3, Tables 1–3)

Material examined

6 females, 5 males, 4 juveniles and 3 four-toed larvae collected sublittorally (1 m in water depth from the mean low tide), medium coarse sand from Henley Beach, Adelaide, South Australia. The sand samples were collected by B.M. on 6 November 1995. Holotype and seven paratypes will be deposited in the Queensland Museum. The other paratypes will be deposited in the Zoological Museum of the University of Copenhagen (ZMUC). Only 14 specimens were measured. In this paper, only the measurements of 12 specimens are given.

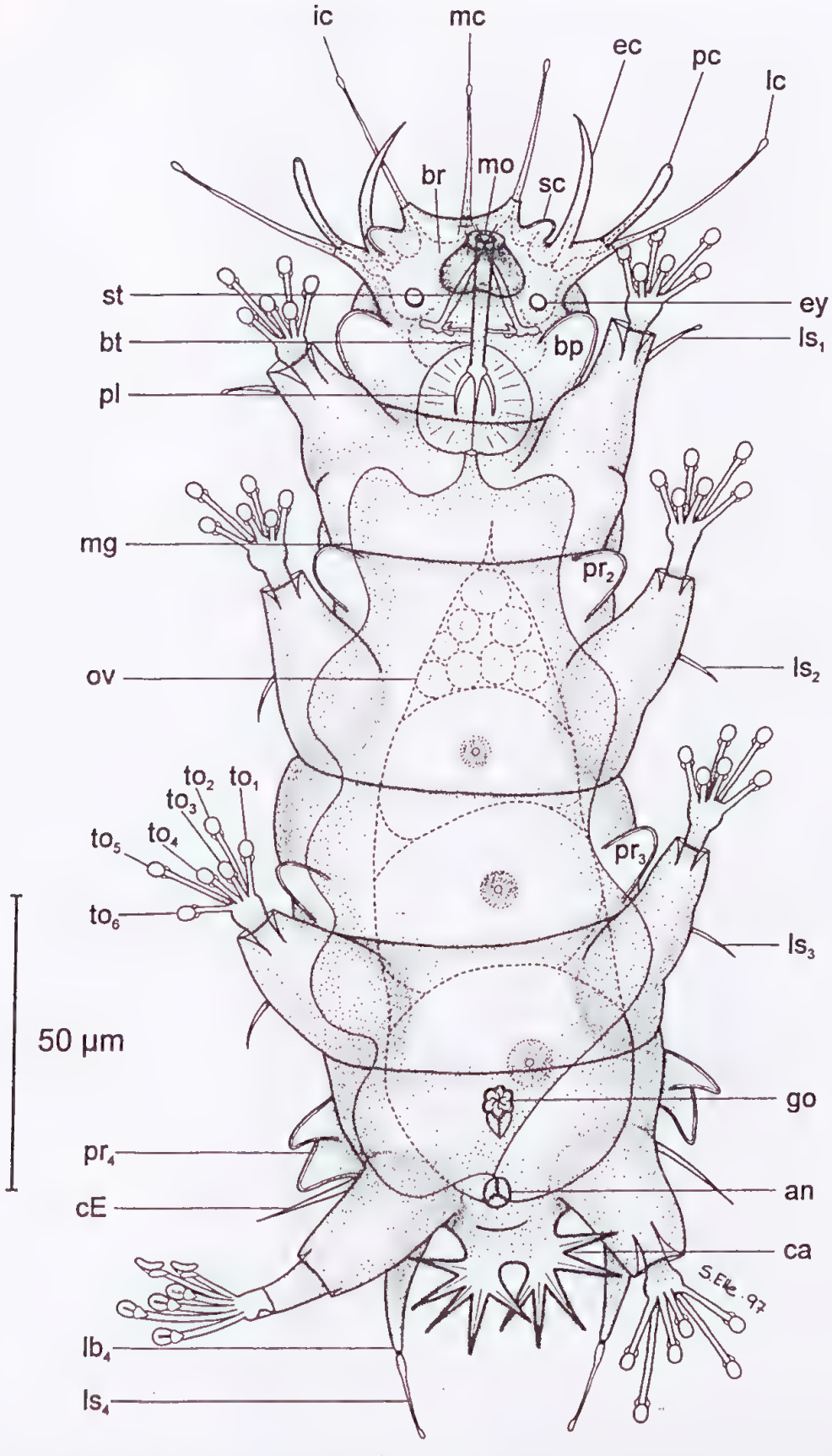

FIGURE 1. *Batillipes lesteri* n. sp. Holotypic female, ventral view. Scale bar equals 50 µm. Abbreviations: an, anus; bl, body length; bp, buccal projection; br, brain; bt, buccal tube; bw, body width; ca, caudal appendage; cE, cirrus E; ec, external cirrus; ey, eye; go, gonopore; ic, internal cirrus; lb_4, the base of leg IV sensory structure; ls_1-ls_3, leg I to leg III spines; ls_4, the spine of leg IV sensory structure; mc, median cirrus; mg, midgut; mo, mouth; oo, oocyte; ov, ovary; pc, primary clava; pl, placoid; pr_2–pr_4, lateral projections; sc, secondary clava; sl, stylet length; ss, stylet support; sv, seminal vesicle; te, testis; to_1-to_6, toe 1 to toe 6.

TABLE 1. Morphometry of *Batillipes lesteri* n. sp. Females. All measurements to the nearest micron.

Specimen	**Holotype Female** (Specimen 1)	**Female 2** large eyes (Specimen 4)	**Female 3** Part. destroyed (Specimen 5)	**Female 4** Immature (Specimen 6)
Body length	178.2 (178)	142.2 (142)	162.5 (163)	115.8 (116)
Body width	72.8 (73)	65.8 (66)	63.8 (64)	49.7 (50)
Buccal tube	25.0 (25)	23.7 (24)	22.0 (22)	20.2 (20)
Stylet length	23.1 (23)	22.5 (23)	20.8 (21)	19.5 (20)
Stylet support	6.0 (6)	6.0 (6)	5.8 (6)	4.8 (5)
Placoid	7.2 (7)	7.2 (7)	7.0 (7)	6.0 (6)
Median cirrus	27.7 (28)	24.4 (24)	25.2 (25)	19.2 (19)
Internal cirrus	29.7 (30)	25.3 (25)	25.5 (26)	21.3 (21)
External cirri	23.2 (23)	17.8 (18)	18.9 (19)	13.8 (14)
Lateral cirri	37.8 (38)	35.6 (36)	35.3 (35)	29.4 (29)
Primary clavae	14.5 (15)	14.9 (15)	12.7 (13)	12.2 (12)
Second. clavae	5.6 (6)	5.1 (5)	5.2 (5)	6.1 (6)
Cirri E	23.2 (23)	21.5 (22)	24.4 (24)	21.0 (21)
Leg IV base	23.1 (23)	19.2 (19)	18.3 (18)	13.4 (13)
Leg IV spine	16.5 (17)	15.0 (15)	15.8 (16)	12.2 (12)
Leg III spine	13.0 (13)	12.1 (12)	10.2 (10)	10.4 (10)
Leg II spine	12.5 (13)	11.9 (12)	10.1 (10)	10.0 (10)
Leg I spine	10.0 (10)	10.5 (11)	9.7 (10)	9.5 (10)
Buccal project.	9.9 (10)	7.7 (8)	8.2 (8)	7.5 (8)
Projection 2	12.5 (13)	8.1 (8)	11.4 (12)	8.9 (9)
Projection 3	13.2 (13)	10.3 (10)	12.3 (12)	9.5 (10)
Projection 4	15.3 (15)	15.2 (15)	13.1 (13)	11.7 (12)
Caudal apparatus	21.0 x 26.4	16.8 x 19.2	20.0 x 15.0	16.0 x 12.9
apparatus	(21 x 26) bilobed,	(17 x 19) bilobed,	(20 x 15) bilobed,	(16 x 13) bilobed,
(width x length)	each with 5 spikes	each with 3 spikes	each with 3 spikes	each with 4 spikes
Leg 1 (toe 1)	9.5 (10)	9.5 (10)	9.5 (10)	9.5 (10)
(toe 2)	5.9 (6)	5.7 (6)	5.6 (6)	5.2 (5)
(toe 3)	12.5 (13)	14.1 (14)	12.8 (13)	12.0 (12)
(toe 4)	7.9 (8)	7.8 (8)	7.9 (8)	7.2 (7)
(toe 5)	17.1 (17)	17.2 (17)	16.1 (16)	15.0 (15)
(toe 6)	10.5 (11)	9.8 (10)	9.8 (10)	10.0 (10)
Leg IV (toe 1)	13.8 (14)	12.9 (13)	12.4 (12)	10.8 (11)
(toe 2)	19.8 (20)	17.0 (17)	18.4 (18)	15.2 (15)
(toe 3)	8.5 (9)	7.5 (8)	7.8 (8)	5.8 (6)
(toe 4)	13.2 (13)	11.7 (12)	11.3 (11)	10.2 (10)
(toe 5)	22.4 (22)	18.2 (18)	21.5 (22)	16.0 (16)
(toe 6)	13.4 (13)	10.6 (11)	11.8 (12)	9.8 (10)
Gonopore/Anus	11.0 (11)	11.2 (11)	10.2 (10)	rosette not present
Ovary	3 eggs	2 eggs	2 eggs	immature
Toe formula	6-6-6-6	6-6-6-6	6-6-6-6	6-6-6-6

Diagnosis

Middle-sized *Batillipes* with large lipoid eyes, swollen tips on lateral, internal and median cirri as well as on fourth leg spine; enlarged fourth leg spine with a van der Land body separating the cirrophore from spinous part of the leg sense organ. The prominent lateral projection between legs III and IV is two-pointed in adults and juveniles, one-pointed in larvae. The caudal apparatus is an ala-like structure with thin cuticular fibres often covered with detritus. This structure varies extremely from simple bilobed to highly furcated (4–10 spikes). Slightly sexually dimorphic (females larger than males); females with wider gonopore-anus distance than males, and females with two-valved cuticular structures associated with the rosette gonopore system. Uneven 3rd (short) and 4th (long) toe on fourth leg, all toes with ovoid suction discs.

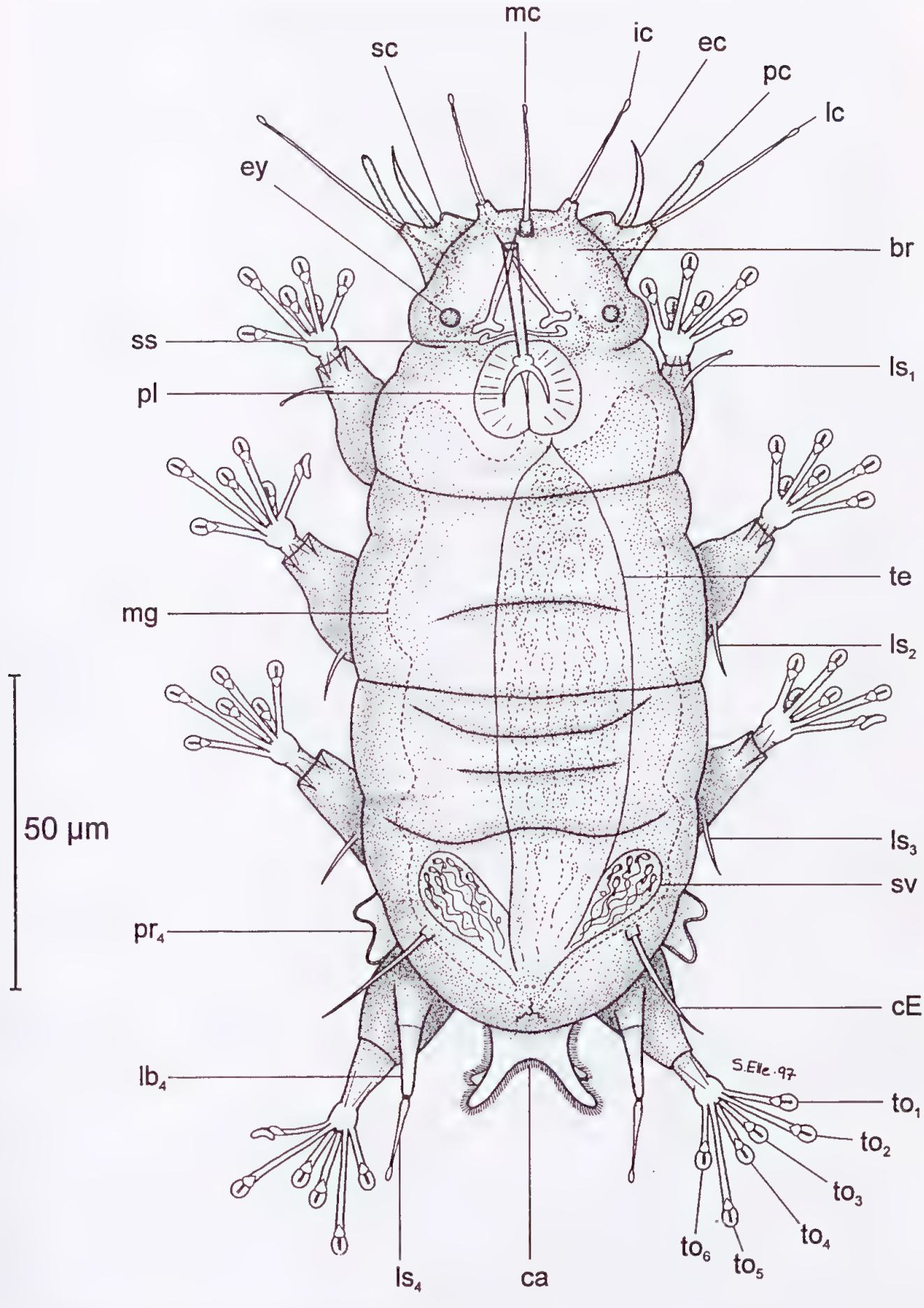

FIGURE 2. *Batillipes lesteri* n. sp. Allotypic male, dorsal view. Scale bar equals 50 µm. Abbreviations as for Fig. 1.

TABLE 2. Morphometry of *Batillipes lesteri* n. sp. Males. All measurements to the nearest micron.

Specimen	**Allotypic male** (Specimen 2)	**Male 2** vent./gonopore (Specimen 7)	**Male 3** lateral (Specimen 8)	**Male 4** Imm. Testis (Specimen 9)
Body length	133.7 (134)	174.2 (174)	129.0 (130)	112.5 (113)
Body width	66.8 (67)	73.5 (73)	lateral view	47.8 (48)
Buccal tube	21.7 (22)	21.8 (22)	18.8 (19)	17.1 (17)
Stylet length	19.8 (20)	21.0 (21)	17.5 (18)	15.3 (15)
Stylet support	5.9 (6)	6.2 (6)	5.3 (5)	5.2 (5)
Placoid	6.6 (7)	7.1 (7)	7.0 (7)	6.0 (6)
Median cirrus	23.0 (23)	28.1 (28)	22.8 (23)	19.8 (20)
Internal cirrus	23.1 (23)	28.9 (29)	23.0 (23)	22.2 (22)
External cirri	19.8 (20)	19.6 (20)	15.4 (15)	14.9 (15)
Lateral cirri	31.5 (32)	38.9 (39)	32.5 (33)	33.1 (33)
Primary clavae	13.8 (14)	15.0 (15)	13.0 (13)	11.7 (12)
Second. clavae	5.2 (5)	5.3 (5)	5.1 (5)	4.9 (5)
Cirri E	21.1 (21)	22.5 (23)	21.0 (21)	20.2 (20)
Leg IV base	18.3 (18)	17.8 (18)	13.5 (14)	15.6 (16)
Leg IV spine	15.8 (16)	18.0 (18)	12.8 (13)	13.3 (13)
Leg III spine	10.5 (11)	13.2 (13)	10.2 (10)	9.8 (10)
Leg II spine	10.5 (11)	12.1 (12)	9.8 (10)	9.4 (9)
Leg I spine	9.5 (10)	12.0 (12)	8.9 (9)	9.1 (9)
Buccal project.	8.0 (8)	9.5 (10)	6.2 (6)	7.2 (7)
Projection 2	9.8 (10)	10.8 (11)	7.5 (8)	9.5 (10)
Projection 3	10.3 (10)	12.2 (12)	8.0 (8)	10.2 (10)
Projection 4	11.8 (12)	15.8 (16)	13.4 (13)	12.9 (13)
Caudal apparatus (width x length)	16.2 x 17.8 (16 x 18) bilobed, each with 2 spikes	15.8 x 16.0 (16 x 16) bilobed, each with 2 spikes	11.5 x 13.0 (12 x 13) bilobed, each with 2 spikes	15.0 x 13.2 (15 x 13) bilobed, each with 2 spikes
Leg 1 (toe 1)	9.9 (10)	10.1 (10)	8.5 (9)	7.2 (7)
(toe 2)	5.9 (6)	6.0 (6)	5.0 (5)	4.9 (5)
(toe 3)	12.5 (13)	15.3 (15)	13.8 (14)	11.9 (12)
(toe 4)	7.9 (8)	9.2 (9)	8.2 (8)	6.1 (6)
(toe 5)	17.1 (17)	18.5 (19)	15.0 (15)	15.2 (15)
(toe 6)	9.2 (9)	11.6 (12)	9.8 (10)	8.0 (8)
Leg IV (toe 1)	12.5 (13)	14.1 (14)	10.2 (10)	10.1 (10)
(toe 2)	18.4 (18)	19.4 (19)	15.8 (16)	14.7 (15)
(toe 3)	8.5 (9)	7.5 (8)	6.2 (6)	5.2 (5)
(toe 4)	11.5 (12)	12.6 (13)	10.1 (10)	10.0 (10)
(toe 5)	21.0 (21)	21.7 (22)	18.2 (18)	15.3 (15)
(toe 6)	11.2 (11)	11.8 (12)	9.4 (9)	9.2 (9)
Gonopore/Anus	3.3 (3)	4.2 (4)	3.0 (3)	2.9 (3)
Testis	mature sperm	mature sperm	without seminal vesicles	without seminal vesicles
Toe formula	6-6-6-6	6-6-6-6	6-6-6-6	6-6-6-6

Description

Holotype

Adult female (Fig. 1) with body 178 µm long measured excluding caudal appendage and 73 µm wide between legs II and III. Head distinguished from body by a constriction beneath lateral cirri and primary clavae. Head width 45 µm between bases of lateral cirri. Median cirrus unpaired, with large cirrophore and swollen tip (28 µm). Internal cirri also with large cirrophores and swollen tips (30 µm) directed anteriorly. External cirri horn-shaped (23 µm long) with indistinct cirrophores. Primary clavae moderately long (15 µm), thick and tube-shaped. Primary clava and lateral cirrus with a common pedestal (cirrophore of lateral cirrus). Primary clava with a thick cuticular annulus (van der Land body) inside base. Lateral

TABLE 3. Morphometry of *Batillipes lesteri* n. sp. Larva and Juveniles. All measurements to the nearest micron.

Specimen	**Four-toed larva** (Fig. 3) (First instar) (Specimen 3)	**Four-toed larva 2** (First instar) (Specimen 10)	**Juvenile 2** (Third instar) (Specimen 11)	**Juvenile 3** (Fourth instar) (Specimen 12)
Body length	76.5 (77)	78.5 (79)	85.8 (86)	105.2 (105)
Body width	29.7 (30)	27.9 (28)	29.7 (30)	43.8 (44)
Buccal tube	16.5 (17)	15.7 (16)	simplex	18.2 (18)
Stylet length	13.8 (14)	15.2 (15)	simplex	16.5 (17)
Stylet support	3.9 (4)	3.8 (4)	simplex	5.0 (5)
Placoid	4.6 (5)	4.2 (4)	simplex	6.3 (6)
Median cirrus	19.5 (20)	18.2 (18)	20.2 (20)	19.1 (19)
Internal cirrus	20.4 (20)	18.9 (19)	21.1 (21)	20.3 (20)
External cirri	10.5 (11)	10.2 (10)	13.2 (13)	14.4 (14)
Lateral cirri	29.7 (30)	28.9 (29)	29.7 (30)	30.7 (31)
Primary clavae	9.5 (10)	9.0 (9)	9.9 (10)	12.6 (13)
Second. clavae	2.6 (3)	3.7 (4)	3.3 (3)	5.0 (5)
Cirri E	19.8 (20)	19.0 (19)	19.1 (19)	20.1 (20)
Leg IV base	9.2 (9)	10.2 (10)	8.5 (9)	12.8 (13)
Leg IV spine	9.2 (9)	9.8 (10)	8.7 (9)	13.0 (13)
Leg III spine	9.9 (10)	9.5 (10)	9.2 (9)	9.3 (9)
Leg II spine	9.9 (10)	9.2 (9)	9.0 (9)	9.0 (9)
Leg I spine	8.5 (9)	8.0 (8)	8.7 (9)	8.7 (9)
Buccal project.	5.9 (6)	5.0 (5)	5.9 (6)	5.8 (6)
Projection 2	6.6 (7)	6.2 (6)	5.9 (6)	6.2 (6)
Projection 3	7.2 (7)	7.4 (7)	7.9 (8)	6.7 (7)
Projection 4	8.5 (9)	10.0 (10)	9.9 (10)	9.1 (9)
Caudal apparatus (width x length)	6.2 x 4.6 (6 x 5) bilobed, each with one spike	8.2 x 10.5 (8 x 11) bilobed with blunt tip	6.8 x 5.2 (7 x 5) bilobed, each with two small spikes	11.2 x 12.7 (11 x 12) bilobed, each with two spikes
Leg 1 (toe 1)	5.2 (5)	5.2 (5)	5.2 (5)	8.2 (8)
(toe 2)	0	0	0	4.9 (5)
(toe 3)	11.2 (11)	12.1 (12)	7.9 (8)	13.7 (14)
(toe 4)	5.2 (5)	6.8 (7)	5.9 (6)	7.0 (7)
(toe 5)	0	0	9.9 (10)	15.0 (15)
(toe 6)	7.2 (7)	8.2 (8)	7.6 (8)	9.6 (10)
Leg IV (toe 1)	7.9 (8)	7.2 (7)	9.9 (10)	9.1 (9)
(toe 2)	14.2 (14)	14.0 (14)	13.2 (13)	15.8 (16)
(toe 3)	0	0	4.6 (5)	5.7 (6)
(toe 4)	0	0	7.9 (8)	9.2 (10)
(toe 5)	11.2 (11)	10.1 (10)	14.5 (15)	16.4 (16)
(toe 6)	8 .2 (8)	8.0 (8)	9.2 (9)	9.0 (9)
Gonopore/Anus	lacking	lacking	gonopore lacking/ anus present	gonopore lacking/ anus present
Toe formula	4-4-4-4	4-4-4-4	5-6-6-6	6-6-6-6

cirri long and tapered terminating in prominent swelling (38 µm). Secondary clavae (base 6 µm) located between internal and external cirri at frontal edge of head. Two large lipoid eyespots present only in live animal consisting of one very large ball-shaped lipoid droplet. The hyalin spherical structure is seen on the inside of the external brain lobe (protocerebrum). It is supposed they are of lipid composition based on their solubility in alcohol and glycerol. Pharyngeal bulb subcircular (18 µm x 21 µm) located between legs I. In optical cross-section, bulb is trilobate, each lobe with a calcium carbonate encrusted placoid (7 µm). Buccal tube straight and moderately long (25 µm) with (3 µm) width. Buccal tube extends inside pharyngeal bulb attaching placoids via three

apophyses. Ventral mouth as in characteristic pouting in typical *Batillipes* form (*sensu* Kristensen 1978). Stylet supports straight (6 µm) with support knob showing slight deflection anteriorly. Support knobs linked on large furca of stylet. Stylets length 23 µm.

Spines present on all legs. Spine of legs I located more distally than all other spines. Spines on legs II–IV located proximally to body. Increasing size of spines from legs I–IV, 10.0 µm, 12.5 µm, 13.0 µm, 16.5 µm + 23.1 µm respectively. Fourth leg spine very long with large base (cirrophore) and a cuticular annulus (van der Land body) separating base from spine which is the true sense organ. Total length of whole fourth leg sensory structure 49.6 µm. First and fourth leg spines with swollen tips as in cephalic cirri. Cirri E moderately long (23 µm) and sharply pointed with distinct cirrophore. Ventral tongue-shaped projections in front of leg I (10 µm), leg II (13 µm long) and leg III (13 µm long). Lateral projection in front of leg IV bifurcate (15 µm long). Caudal apparatus ala-like and strongly furcated (2 x 5 spikes). Cuticle of caudal apparatus has fine hairs; it is covered with bacteria and detritus. Gonopore rosette-shaped with six identical segments. Behind the female gonopore there is a two valved cuticular structure. Gonopore-anus distance is 11 µm. The holotypic female is sexually mature, with three large eggs.

Legs I–IV possessing toes of varying lengths. On leg I, toe 5 is the longest (17 µm) with toes decreasing in size 3, 6, 1, 4 and 2 (13 µm, 11 µm, 8 µm and 6 µm respectively). On legs IV, toes 2 and 3 are unequal in size and conform to toe pattern D (see Table 5). Length of toes in decreasing order of size is 5, 22 µm; 2, 20 µm; 1, 14 µm; 4, 13 µm; 6, 11 µm and 3, 9 µm. Toe discs ovate with conspicuous brace.

Allotype

Adult male (Fig. 2) with body 134 µm long measured excluding caudal appendage, and 67 µm wide between legs II and III. Male is similar to female except for size and differences in shape of projection in front of leg IV which is slightly bilobate, and caudal appendage lobate with only four spikes. Gonopore-anus distance is only 3 µm, meaning that the gonopore nearly connects the anterior branch of a three-lobed anal system. Male gonopore located on a small ovoid papilla. The allotype is sexually mature with two lateral seminal vesicles filled with mature spermatozoa.

The allotype is drawn in dorsal perspective. Dorsal transverse lines indicating segmental plates disappear after fixation. The punctations of the dorsal cuticle (see McKirdy 1975) are very coarse, especially laterally, where the epicuticular pillars, which form the punctations, can be seen using light microscopy. Each lateral pillar is about 2 µm high.

Four-toed larva

The first instar of all species of *Batillipes* is so different from subsequent instars, that the term 'larva' (*sensu* Bertolani *et al.* 1984) is correct. The paratypic larva illustrated (Fig. 3, Table 3) has a body length of 77 µm and body width of 30 µm. It shows typical ontogenetic body proportions with a larger head region in relation to body, lacks the gonopore, the anus is only a slit, and it is not three-lobed. The larva has only four toes instead of the six toes of the adult. Toe 2 and 5 are missing on legs I–III and toes 3 and 4 are missing on leg IV. The leg spines I–III are with a swollen tip, but the leg spine IV is pointed. The projection 4 has only one spike and the caudal appendage is only slightly bilobed.

Juvenile

The animals without gonopore, but with three-lobed anus are called juveniles. At least two instars can be recognized but they could be more numerous. The second instar has the toe formula 5-5-5-6 and the third instar has 5-6-6-6. All sense organs have the characteristics of the adult, but the projection in front of leg IV and the caudal apparatus vary a lot. The differences between males and females can be seen in the size and especially in the caudal apparatus.

Young adults

Animals with gonopores, but with immature reproductive systems are called young females and males. These animals are smaller in size, but are still sexually dimorphic. The young males lack the seminal vesicles with mature spermatozoa while the young females have only small-size oocytes in the ovaries.

Life Cycle

There is no doubt that *B. lesteri* was in the middle of its reproductive cycle when the specimens were collected in November, which is the last month in the Australian Spring. It is unusual to have so many four-toed larvae and juveniles in populations of *Batillipes*. The first instar, the four-toed larva, differed dramatically from the juveniles and adults. It is difficult to interpret just how many instars are involved

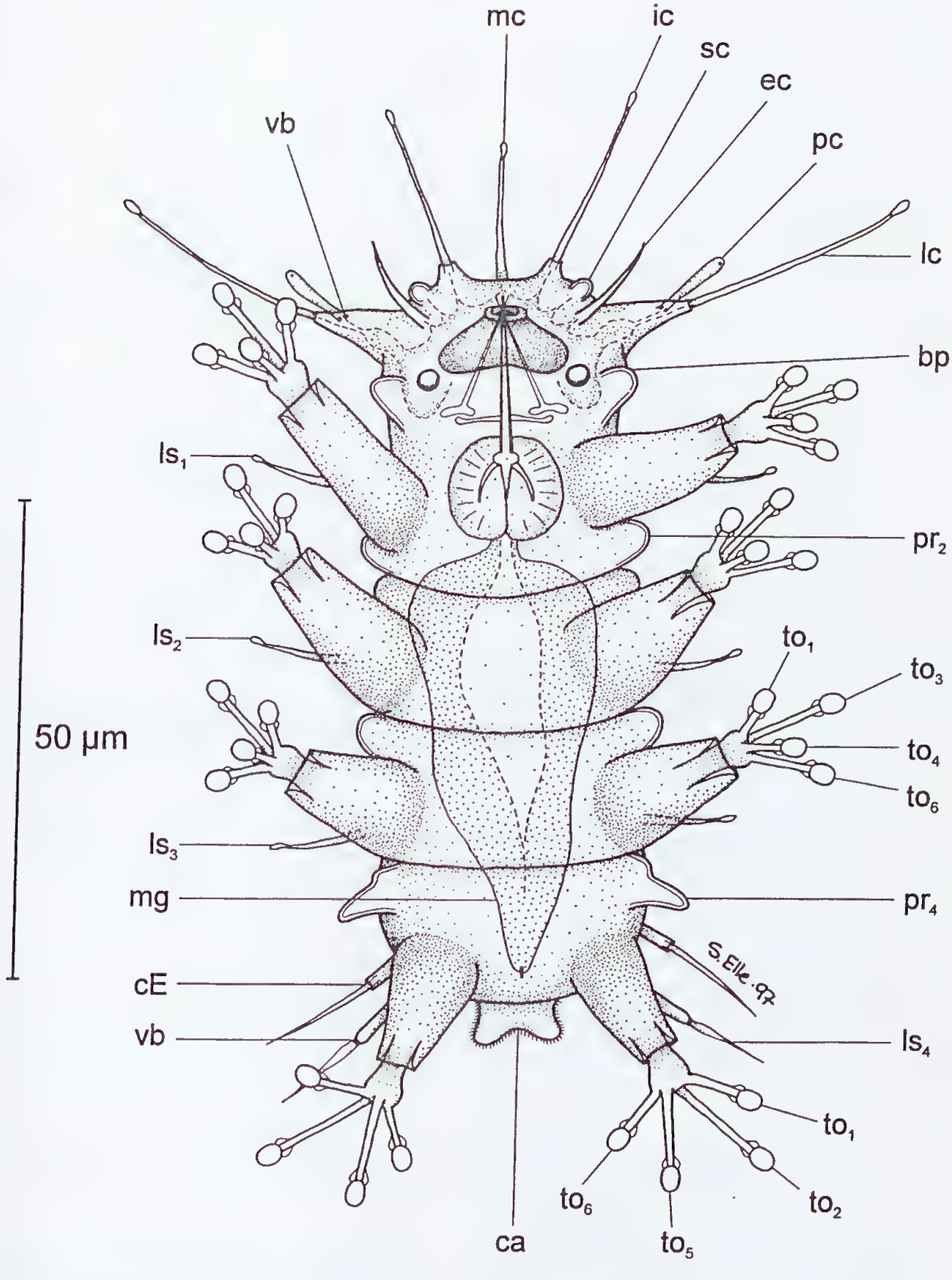

FIGURE 3. *Batillipes lesteri* n. sp. Paratypic four-toed larva. Scale bar equals 50 µm. Abbreviations as for Fig. 1.

TABLE 4. Zoogeographic distribution of species of the genus *Batillipes*. (Southern hemisphere records in bold).

B. acaudatus – England (Pollock, 1971)
B. adriaticus – Italy – (Grimaldi De Zio *et al.*, 1979)
B. africanus – Libéria (Morone De Lucia *et al.*, 1988)
B. annulatus – Italy (De Zio 1962, Grimaldi De Zio *et al.* 1979)
B. bullacaudatus – USA (McGinty & Higgins 1968, Pollock 1970b; Lindgren 1971; McKirdy 1975); Scotland (McIntyre & Murison 1973)
B. carnonensis – France (Fize 1957); Italy (Grimaldi De Zio *et al.* 1980, 1983); USA (Fleeger 1978)
B. crassipes – Russia (Tchesunov & Mokievsky 1995); Korea (Rho *et al.* 1999)
B. dicrocercus – USA (Pollock 1970a, McKirdy 1975, Hummon 1994); Italy (Hummon 1994; Grimaldi De Zio *et al.* 1980, D' Addabbo Gallo *et al.* 1987, Matarrese *et al.* 1996); Poland (Hummon 1994)
B. friaufi – USA (Riggin 1962, McKirdy 1975, Gaugler & Nelson 1997)
B. gilmartini – USA (McGinty 1969. Pollock 1989)
B littoralis – France (Renaud-Debyser 1959, D'Hondt 1970, Renaud-Debyser & Salvat 1963); Italy (Grimaldi De Zio *et al* . 1983, D'Addabbo Gallo *et al* 1987, D'Addabbo Gallo *et al.* 1999, Grimaldi De Zio *et al.* 1999)
B. longispinosus – Korea (Chang & Rho 1997a, Rho *et al.* 1999)
B. marcelli – Italy (Morone De Lucia *et al.* 1988)
B. mirus – Germany (Richters 1909); Wales (Boaden 1963); Ireland (Boaden 1966); Scotland (Pollock 1971; McIntyre & Murison 1973); Norway (Tambs-Lyche 1939–40); Denmark (Fenchel *et. al* 1967, Fenchel 1969, Kristensen 1978); Finland (Purasjoki 1953, Karling 1954–1955); Sweden (Jägersten 1952); North Sea (Remane 1940, Freidrich 1963); Black Sea (Plesa 1963); Germany (Schmidt 1969) Bulgaria (Valkanov 1950, 1954); Romania (Rudescu 1964); Russia (Petelina & Tchesunov 1983, Biserov 1991); France (Baudoin 1952, Swedmark 1956 a,b, Renaud- Debyser 1956, Guérin 1960, Renaud-Mornant & Jouin 1965; D'Hondt 1970,Renaud-Debyser & Salvat 1963); Italy (Papi 1952, D'Addabbo Gallo *et al.* 1987); **Madagascar (Renaud-Mornant 1979)**; USA (Hay 1917, King 1962, McGinty & Higgins 1968, Pollock 1970a, Lindgren 1971, McKirdy 1975, Meyer cited in Pollock 1989, Pollock 1989, Gaugler & Romano 1995, Gaugler & Nelson 1997); Bahamas (Pollock 1970b); **Malaysia (Renaud-Mornant & Serène 1967)**
B. noerrevangi – Denmark (Kristensen 1976, 1978)
B. orientalis – Korea (Chang & Rho 1997, Rho *et al.* 1999))
B. pennaki – Massachusetts, USA (Marcus 1946, Pollock 1970b, McKirdy 1975); **Brazil (Marcus 1946);** France (Renaud-Debyser 1959,Renaud-Debyser & Salvat 1963); Italy (De Zio 1962, 1964, Grimaldi de Zio & D'Addabbo Gallo 1975, Grimaldi De Zio *et al.* 1979, Bertolani *et al.* 1984, D'Addabbo Gallo *et al.* 1987); Spain (Villora-Mofeno & Grimaldi de Zio 1993); India (Rao & Ganapati 1968); Korea (Rho *et al.* 1999)
B. philippinensis – Philippines (Chang & Rho 1997b); Korea (Rho *et al.* 1999)
B. phreaticus – France (Renaud-Debyser 1959, Renaud-Debyser & Salvat 1963); Germany (Riemann 1966); England (Pollock 1971); Spain (Villora-Moreno & Grimaldi De Zio 1993); Italy (D'Addabbo *et al.* 1987).
B. roscoffensis – France (Kristensen 1978)
B. rotundiculus – Korea (Rho *et al.* 1999)
B. similis – Germany (Schulz 1955); Korea (Rho *et al.* 1999) France (Fize 1963); Italy (Grimaldi De Zio *et al.* 1980, D'Addabbo Gallo *et al.* 1999, Grimaldi De Zio *et al.* 1999)
B. tridentatus – Washington & California, USA (Pollock 1989); Korea (Rho *et al.* 1999)
B. tubernatis – Scotland (McIntyre & Eleftheriou 1968, Pollock 1971); Germany (Riemann 1966, Hummon 1994); USA (McKirdy 1975)

before an animal is sexually matured but at least four moults are present before the gonopore is seen. The following instars have been recorded for this species. First instar –the four toed larvae; Second instar – juvenile with toe formula 5-5-5-6; Third instar – juvenile with toe formula 5-6-6-6; Fourth instar juvenile without gonopore but with toe formula 6-6-6-6; Adult—with gonopore and three-lobed anus.

Etymology

Named in honour of curator Dr Lester R. G. Cannon, Queensland Museum, who facilitated our collaboration.

TABLE 5. Patterns of toe length on fourth foot of species of *Batillipes*. (Modified after Pollock 1970a)

A (III & IV equal)	B (I & III equal)	C (II & IV equal)	D (III & IV unequal)
B. acaudatus	*B. phreaticus*	*B. friaufi*	*B. africanus*
B. adriaticus		*B. littoralis*	*B. lesteri*
B. annulatus			*B. tubernatis*
B. bullacaudatus			*B. similis*
B. carnonensis			
B. crassipes			
B. dicrocercus			
B. gilmartini			
B. longispinosus			
B. marcelli			
B. mirus			
B. noerrevangi			
B. orientalis			
B. pennaki			
B. philippinensis			
B. roscoffensis			
B. rotundiculus			
B. tridentatus			

Systematic Discussion

Species of the genus *Batillipes* are amongst the most studied of all marine tardigrades. Their taxonomy remains problematic with relatively few characters commonly used in systematic investigations of the group (McKirdy 1975). Some of the characters used (e.g. conformation of lateral body projections, relative length and shape of cephalic appendages), are directly affected by the physical mounting process. Total body length and width may vary due to cover slip pressure; shrinkage can occur due to the mounting medium and lengths of spines and cirri may be miscalculated because of their orientation to the observer. Internal features such as eyespots and buccal apparatus can also be affected by mounting media and cover slip pressure. Apart from these mechanical problems, there are also a range of other factors to contend with. The caudal appendage of *Batillipes* has often been used in the diagnosis of species but various authors have shown this can vary ontogenetically (Grimaldi de Zio and D'Addabbo Gallo 1975; Morone De Lucia *et al.* 1988). Further ontogenetic variation has been recorded by Kristensen (1978), McGinty and Higgins (1968) and Villora-Morena and Grimaldi de Zio (1993).

Comparative studies have also been made difficult because of the inconsistent nomenclature of toes and the lack of a full range of specimens of both sexes, four-toed larvae and juveniles for many species. In this study, we have used the standard method of numbering toes on the fourth leg with toe 1 being the closest cranially on the right hand side and the toes then numbered sequentially in a clockwise direction. This makes the caudoproximal toe, toe 6 in our scheme (Table 5). Furthermore, the attachment of the toes to the tarsus has systematic value in determining which toe is missing in larvae and in juveniles. At leg 1, the 2nd and 4th toes are ventral, 1st and 6th lateral and 3rd and 5th dorsal on the tarsus. This distribution is functionally correct: the shortest toes are ventral and the longest dorsal.

The relative position of these toes, particularly those on right leg IV has been used as an important taxonomic indicator (Pollock 1970a). Even here problems can arise if the legs are not properly positioned or incorrectly illustrated. It is therefore necessary to have a range of specimens, of both sexes, including juveniles if any meaningful taxonomic decisions are to be made. *Batillipes lesteri* n. sp. differs from all other species of *Batillipes* by having uneven 3rd and 4th toes on leg IV except for *B. africanus, B. similis* and *B. tubernatis*. It differs from *B. tubernatis* by having a caudal apparatus with fine cuticular hairs and differs from *B. africanus* by the males having bilobate caudal appendages with four spikes and females having highly furcated (6–10 spikes) caudal appendages. It differs from *B. similis* by

having different primary clava as well as caudal and lateral processes.

Ontogenetic differences between other species of *Batillipes* are seen in the toe formula. Larvae of *B. noerrevangi* lack toe 2 (the smallest one of the adult) and toe 6 on leg I. Larvae of *B. lesteri* also lack toe 2 but instead of toe 6, they lack toe 5 (the longest toe in the adult) on leg I.

Marine tardigrades also go through a life cycle with a number of moults and will vary morphologically at different stages of this cycle including a process called cyclomorphosis (Kristensen 1982) Furthermore the species may vary in morphology according to differences in salinity (Kristensen 1978). A proper analysis of both sexual and ontogenetic variations is necessary in many instances before new taxa should be raised.

The new species of *Batillipes* is only the third recorded for the Southern Hemisphere. A zoogeographic analysis of the 24 species recorded so far (Table 4) shows a singular distributional bias towards the northern hemisphere. This is probably more an artefact of where marine tardigradologists have been working and collecting rather than any zoogeographic pattern. In this analysis, most *Batillipes* species are still primarily known from their type localities with only three species *B. mirus*, *B. pennaki* and *B. phreaticus* having more cosmopolitan distributions.

Several studies have shown that certain species of *Batillipes* live sympatrically occupying specific regions of the littoral environment (Renaud-Debyser 1959, Schmidt 1969, Lindgren 1971). Furthermore, Renaud-Debyser (1959) and Pollock (1975) have demonstrated that *Batillipes* shows tolerances and preferences to water content, temperature, light and salinity. This predicates that any understanding of the distribution of species of *Batillipes* at any location must take all these factors into account. Some beaches may have an almost monotypic batilliped fauna while others may support several species in different locations. Further ecological studies and collecting of Australian marine tardigrades is needed to clarify whether these patterns hold true in southern latitudes.

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References

BAUDOIN, R. 1952. Contribution à l'écologie et à la biogéographie de la zone intercôtidale des Charentes. *Compte Rendu des Séances de la Société de Biogéographie.* **215:** 72–82.

BERTOLANI, R., GRIMALDI DE ZIO, S., D'ADDABBO GALLO, M. & MORONE DE LUCIA, M. R. 1984. Postembryonic development in heterotardigrades. *Monitore Zoologico Italiano* (N.S.) **18:** 307–320.

BISEROV, V. I. 1991. An annotated list of Tardigrada from European Russia. *Zoologische Jahrbücher, Abteilung für Systematik Ökologie und Geographie der Tiere* **118:** 193–216.

BOADEN, P. J. S. 1963. The interstitial fauna of some North Wales beaches. *Journal of the Marine Biological Association of the United Kingdom* **43:** 79–96.

BOADEN, P.J.S. 1966. Interstitial fauna from Northern Island. *Veröffentlichungen des Instituts für Meeresforschung in Bremerhaven* **2:** 125–130.

CHANG, C. Y. & RHO, H. S. 1997a. Two New Marine Tardigrades of Genus *Batillipes* (Heterotardigrada: Batillipedidae) from Korea. *Korean Journal of Systematic Zoology* **13:** 93–102.

CHANG, C. Y. & RHO, H. S. 1997b. Two New Marine Tardigrades from Palawan Island, the Philippines. *Korean Journal of Biological Science* **1:** 419–423.

D'ADDABBO GALLO, M., GRIMALDI DE ZIO S. & MORONE DE LUCIA, M. R., 1999. Diversity and dynamics of an interstitial Tardigrada population in the Meloria Shoals, Ligurian Sea, with a redescription of *Batillipes similis* (Heterotardigrada, Batillipedidae). *Italian Journal of Zoology* **66:** 51-61.

D'ADDABBO GALLO, M., MORONE DE LUCIA, M.R., GRIMALDI DE ZIO, S. 1987. Heterotardigrada of the Amendolara Shoal, High Ionian Sea. Pp. 103–110 *in* 'Biology of Tardigrades'. Ed. R. Bertolani. Proceedings of the 4th International Symposium on the Tardigrada. Modena, September 3–5, 1985. Collana U.Z.I. Selected Symposia and Monographs 1.

DE ZIO, S. 1962. Descrizione di *Batillipes annulatus* n. sp. e note su *B. pennaki* Marcus nuovo rinvenimento nel Mediterraneo (Heterotardigrada) *Annuario dell'Istituto e Museo di Zoologia della Università di Napoli* **14:** 1–7.

D'HONDT, J. -L. 1970. Gastrotriches, Kinorhynques, Rotifères, Tardigrades. Inventaire de la Faune marine de Roscoff. Ed. Station Biologique Roscoff. Pp. 1–29.

FENCHEL, T., 1969. The ecology of marine microbenthos IV. Structure and function of the benthic ecosystem, its chemical and physical factors and the macrofauna communities with special reference to the ciliated protozoa. *Ophelia* **6:** 1–182.

FENCHEL, T., JANSSON, B. O. & THUN, W. V. 1967. Vertical and horizontal distribution of the metazoan microfauna and of some physical factors in a sandy beach in the northern part of the Oresund. *Ophelia* **4:** 227–243.

FIZE, A. 1957. Description d'une espèce nouvelle de Tardigrade *Batillipes carnonensis* n. sp. *Bulletin de la Société Zoologique de France* **82:** 430–433.

FIZE, A. 1963. Contribution a l'étude de la microfaune des sables littoraux du Golfe d'Aigues-Martes. *Vie et Milieu* **14:** 669–774.

FLEEGER, J. W., 1978. Free-living invertebrates. Phylum Tardigrada. Pp. 224 *in* 'An Annotated Checklist of the Biota of the Coastal Zone of South Carolina'. Ed. R. G. Zingmark. University of South Carolina Press: Columbia.

FREIDRICH, H. 1963. Kurze Notizen sur marinen Fauna der Aussenweser. *Veröffentlichungen des Instituts für Meeresforschung in Bremerhaven* **8:** 109

GAUGLER, M. S. & NELSON, D. R. 1997. Marine interstitial tardigrades of Dauphin Island, Alabama [USA]. *Association of Southern Biologists Bulletin* **44:**112.

GAUGLER, M.S. & ROMANO, F. A. 1995. A preliminary survey of marine sand tardigrades of Dauphin Island, Alabama. *Journal of the Alabama Academy of Science* **66:**14.

GRIMALDI DE ZIO, S. & D'ADDABBO GALLO, M. 1975. Reproductive cycle of *Batillipes pennaki* Marcus (Heterotardigrada) and observations on the morphology of the female genital apparatus. VII European Marine Biology Symposium Sorrento (Naples) 1973. *Pubblicazioni Stazione Zoologica di Napoli*, Supplement **39:** 212–225.

GRIMALDI DE ZIO, S., D'ADDABBO GALLO, M. & MORONE DE LUCIA, M. 1983. Marine tardigrades of the 'Secca dell Armeleia' (Ionian Sea), and redescription of *Raiarctus colurus* Renaud-Mornant 1988 (Heterotardigrada). *Oebalia* **9:** 33–42.

GRIMALDI DE ZIO, S., D'ADDABBO GALLO, M. & MORONE DE LUCIA, M. & GRIMALDI, P., 1980. Ulteriori dati sui Tardigradi del mesopsammon di alcune spiagge pugliesi. *Thalassia Salentina* **10:** 45–65.

GRIMALDI, DE ZIO, S., D'ADDABBO GALLO M., MORONE DE LUCIA, M. R., SANDULLI, R., D'ADDABBO, R., FAIENZA, M. G. & PIETANZA, R. 1999. First data on subtidal Meiofauna of Termiti Islands. *Biologia Marina Mediterranea* **6:** 380–382.

GRIMALDI, DE ZIO, S., MORONE DE LUCIA, M. R., D'ADDABBO GALLO, M. & GRIMALDI, P. 1979. Osservazioni su alcuni tardigradi di una spiaggia publiese e descrizione di *Batillipes adriaticus* sp. nov. (Heterotardigrada). *Thalassia Salentina* **9:** 39–50.

GUÉRIN, M. 1960. Observations écologiques sur *Convoluta roscoffensis* Graf. *Cahiers de Biologie Marine* **1:** 205–220

HAY, W. P. 1917. A new species of bear-animacule from the coast of North Carolina. *Proceedings of the United States National Museum* **53**(2203)**:** 251–254.

HUMMON, W. D. 1994. Trans and Cis-Atlantic distributions of three marine heterotardigrades. *Transactions of the American Microscopical Society* **113:** 333–342.

JÄGERSTEN, G. 1952. Studies on the morphology, larval development, and biology of *Protodrilus*. *Zoologiska Bidrag från Uppsala.* **29:** 425–512

KARLING, T. G. 1954–1955. Uber einige Kleintiere des Meeressandes des Nordsee-Ostsee-Gebietes. *Arkiv für Zoologie* **7:** 241–249.

KING, C. E. 1962. The occurrence of *Batillipes mirus* Richters (Tardigrada) in the Gulf of Mexico. *Bulletin of Marine Science of the Gulf and Caribbean* **12:** 201–203.

KRISTENSEN, R. M. 1976. On the fine structure of *Batillipes noerrevangi* Kristensen 1976. 1. Tegument and moulting cycle. *Zoologischer Anzeiger* **197:** 129–150.

KRISTENSEN, R. M. 1978. Notes on marine Heterotardigrada. 1. Description of two new *Batillipes* species, using the electron microscope. *Zoologischer Anzeiger* **200:** 1–17

KRISTENSEN, R. M. 1982. The first record of cyclomorphosis in Tardigrada based on a new genus and species from Arctic meiobenthos. *Zeitschrift für Zoologische Systematik und Evolutionforschung* **20:** 249–270.

KRISTENSEN, R. M. & HIGGINS, R. P. 1984. A new family of Arthrotardigrada (Tardigrada: Heterotardigrada) from the Atlantic Coast of Florida. *Transactions of the American Microscopical Society* **103:** 295–311.

LINDGREN, E. W. 1971. Psammolittoral marine Tardigrades from North Carolina and their conformity to worldwide zonation patterns. *Cahiers de Biologie Marine* **12:** 481–96.

McGINTY, M. M. 1969. *Batillipes gilmartini*, a new marine tardigrade from a California beach. *Pacific Science* **23:** 394–396.

McGINTY, M. M. & HIGGINS, R. P. 1968. Ontogenetic variation of taxonomic characters of two marine tardigrades with the description of *Batillipes*

bullacaudatus n. sp. *Transactions of the American Microscopical Society* **87:** 252–262.

McINTYRE, A. D. & MURISON, D. J. 1973. The meiofauna of a flatfish nursery ground. *Journal of the Marine Biological Association of the United Kingdom* **53:** 93–118.

McKIRDY, D. J. 1975. *Batillipes* (Heterotardigrada): comparison of six species from Florida (USA) and a discussion of taxonomic characters within the genus. *Memorie dell'Istituto Italiano di Idrobiologia Pallanza* **32** suppl.: 177–223.

MACKNESS, B. S. 1999. New records of marine tardigrades (Arthrotardigrada) from Victoria. *Proceedings of the Royal Society of Victoria* **111:** 303–308.

MARCUS, E. 1929. Tardigrada. *In* 'Klassen und Ordnungen des Tierreichs', Bnd 5, Abt. IV, Buch 3. Ed. H. G. Bronn. Leipzig. 608p.

MARCUS, E. 1946. *Batillipes pennaki*, a new marine Tardigrada from the north and south American Atlantic coast. *Comunicaciones Zoológicas del Museo de Historia Natural de Montevideo* **2:** 1–3.

MATARRESE, A., TURSI., A., GRIMALDI DE ZIO, S., GALLO D'ADDABBO, M & MORONE DE LUCIA, M. R. 1996. Ulteriori osservazioni sul Macrobenthos (Echinodermi e Tunicati) e sul meiobenthos delle Isole Eoile. Pp 333–350 *in* 'Caratterisazione Ambientale Marina del Sistema Eolie e dei Bacini Limitrofi de Cefalù e Gioia'. Ed. M. F. Faranda & P. Povero. EOCUMM 95.

MORONE DE LUCIA, R. M., D'ADDABBO, D. & GRIMALDI DE ZIO, S. 1988. Descrizione di due nuove specie di Batillipedidae (Tardigrada, Heterotardigrada). *Cahiers de Biologie Marine* **29:** 361–373.

PAPI, F. 1952. Su alcuni Tardigradi raccolti nell' Italia centrale. *Atti della Società Toscana di Scienze Naturali, Processi Verbali e Memorie, Serie B* **59:** 116–118.

PETELINA, O. YU. & TCHESUNOV, A. V. 1983. A new representative of the fauna of the White Sea *Hypsibius apelloefi* (Tardigrada). *Zoologischeskii Zhurnal* **62:** 177–20.

PLESA, C. 1963. Etude sur la faune interstitielle littorale de la Mer Noire. *Vie et Milieu* **14:** 775–813.

POLLOCK, L. W. 1970a. *Batillipes dicrocercus* n. sp. *Stygarctus granulatus* n. sp., and other Tardigrada from Woods Hole, Massachusetts, USA. *Transactions of the American Microscopical Society* **89:** 38–52.

POLLOCK, L. W. 1970b. Distribution and dynamics of interstitial Tardigrada at Woods Hole, Massachusetts, U.S.A. *Ophelia.* **7:** 145–166.

POLLOCK, L. W. 1971. On some British marine Tardigrada including two new species of *Batillipes*. *Journal of the Marine Biological Society of the United Kingdom* **51:** 93– 103.

POLLOCK, L. W. 1975. The role of three environmental factors in the distribution of the interstitial tardigrade *Batillipes mirus* Richters. *Memorie dell'Istituto Italiano di Idrobiologia Pallanza* **32** suppl.: 305–324.

POLLOCK, L. W. 1989. Marine interstitial Heterotardigrada from the Pacific Coast of the United States, including a description of *Batillipes tridentatus* n. sp. *Transactions of the American Microscopical Society* **108:** 169–189.

PURASJOKI, K. 1953. Zwei verbesserte Apparate zum Auffangen von Kleintieren des See- und Meeresbodens. *Archivum Societatis Zoologicae-Botanicae Fennicae 'Vanamo'* **8:** 110–114.

RAO, G. C. 1971. On two species of marine interstitial Tardigrada from the east coast of India. *Proceedings of the Indian Academy of Sciences, Section B* **73**(2): 53–57.

RAO, G. C. & GANAPATI, P. N. 1968. The interstitial fauna inhabiting the beach sands of Waltair coast. *Proceedings of the National Institute of Sciences in India. Part B Biological Sciences* **34:** 82–125.

REMANE, A. 1940. Einführung in die zoologische Ökologie der Nord- und Ostsee. *In* 'Tierwelt Nord- und Ostsee'. Eds G. Grimpe and E. Wagler. Lieferung **34:** 1–238.

RENAUD-DEBYSER, J. 1956. Répartition de deux Tardigrades *Batillipes mirus* Richters et *Stygarctus bradypus* Schulz dans un segment de plage du Bassin d'Arcachon. *Compte Rendu de l'Académie des Sciences (Paris)* **243:** 1365–1379.

RENAUD-DEBYSER, J. 1959. Sur quelques Tardigrades du Bassin D'Arcachon. *Vie et Milieu* **10:** 135–146.

RENAUD-DEBYSER, J. & SALVAT, B. 1963. Éléments de prospérité des biotopes des sédiments meubles intertidaux et écologie de leurs populations en microfaune et macrofaune. *Vie et Milieu* **14:** 463–550.

RENAUD-MORNANT, J. 1979. Tardigrades marins de Madagascar. I. Halechiniscidae et Batillipedidae. *Bulletin du Muséum National d'Histoire Naturelle, Paris* **1:** 257–277.

RENAUD-MORNANT, J. & JOUIN, C. 1965. Note sur la microfaune du fond à *Amphioxus* de Graveyron et d'autres stations du Bassin d'Arcachon. *Actes de la Société Linnéene de Bordeaux* **102:** 1–7.

RENAUD-MORNANT, J. & SERENE, P. 1967. Note sur la microfaune de la côte orientale de la Malaisie. (Gastrotriches, Annélides, Tardigrades et Copépodes Harpacticides). *Cahiers du Pacifique* **11:** 51–73.

RHO, H. S., MIN, B. H. & CHANG, C. Y. 1999. Taxonomic study of Marine Tardigrades from Korea. 1. Genus *Batillipes* (Heterotardigrada: Batillipedidae). *The Korean Journal of Systematic Zoology* **15**(1): 107–118.

RICHTERS, F. 1909. Tardigraden Studien. *Berichte der Senckenbergischen Naturforschenden Gesellschaft in Frankfurt A.M.* **40:** 28–45.

RIEMANN, F. 1966. Die Verbreitung der interstillen Fauna im Elbe-Aestuar. *Veröffentlichungen des Instituts für Meeresforschung in Bremerhaven* **2:** 114–123.

RIGGIN, G. T. 1962. Tardigrada of southwest Virginia: With the addition of a description of a new species from Florida. *Virginia Agricultural Experimental Station Technical Bulletin* **152:** 1–145.

RUDESCU, L. 1964. Tardigrada. In *Fauna Republicii Populare Romine* **7:** 1–400.

SCHMIDT, P. 1969. Die quantitative Verteilung und Populationsdynamik des Mesopsammons am Gezeiten-Sandstrand der Nordseeinsel Sylt II. Quantative Verteilung und Populationsdynamik einzelner Arten. *Internationale Revue der gesamten Hydrobiologie* **54:** 95–174.

SCHULZ, E. 1955. Studien an marinen Tardigraden. *Kieler Meeresforschung* **11:** 73–79.

SWEDMARK, B. 1956(a). Nouveaux gastrotriches Macrodasyoïdes de la région de Roscoff. *Archives de Zoologie Expérimentale et Générale* **94:** 43–57.

SWEDMARK, B. 1956(b). Etude de la microfaune des sables marins de la région de Marseille. *Archives de Zoologie Expérimentale et Générale. Notes et Revue* **2:** 70–95.

TAMBS-LYCHE, H. 1939-1940. Marine Tardigraden bei Bergen. *Bergens Museums Årbok 1939–40, Naturvitenskabelig rekke* **5:** 1–5.

TCHESUNOV, A. V. & MOKIEVSKY, V. O. 1995. A new marine tardigrade, *Batillipes crassipes* sp. nov., from the Japan Sea (Tardigrada Arthrotardigrada, Batillipedidae). *Cahiers de Biologie Marine* **36:**153–157.

VALKANOV, A. 1950. *Echiniscoides sigismundi* (M. Schultze) ot Czerno More. *Trudy Murmanskogo Morskogo Biologicheskogo Instituta* **15:** 181–186.

VALKANOV, A. 1954. Czernomorskye Tardigradi. Die Tardigraden des Schwarzen Meeres. *Sofücki universitet* **48:** 59–61.

VILLORA-MORENO, S. & GRIMALDI DE ZIO, S. 1993. Redescription and ecology of *Batillipes phreaticus* Renaud-Debyser, 1959 (Arthrotardigrada, Batillipedidae) in the gulf of Valencia (Western Mediterranean). *Cahiers de Biologie Marine* **34:** 387–399.

THREE NEW SPECIES OF *TIPORUS* WATTS (COLEOPTERA: DYTISCIDAE) WITH REDESCRIPTIONS OF THE OTHER SPECIES IN THE GENUS

C. H. S. WATTS

WATTS, C. H. S. 2000. Three new species of *Tiporus* (Coleoptera; Dytiscidae) with redescriptions of the other species in the genus. *Records of the South Australian Museum* 33(2): 89–99.

Three new species of *Tiporus* Watts, 1985 (Coleoptera: Dytiscidae) are described and figured: *Tiporus georginae, T. lachlani* and *T. moriartyensis*. The original descriptions of the existing species were based on a small number of specimens. Recent collections have allowed these descriptions to be reviewed and, where necessary, corrected and/or enlarged. A key is given to the 11 known species.

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The genus *Hypodes* Watts, 1978, later changed due to preoccupation to *Tiporus* Watts, 1985, was erected for a group of small to moderate sized Australian Hydroporini related to *Antiporus* Sharp. Members of *Tiporus* are distributed across coastal Northern Australia where they appear to be restricted to rivers and streams, or to the small pools which form in their beds in the dry season. In these habitats some species, such as *T. undecimmaculatus* and *T. josepheni,* are often abundant.

The genus has not been reviewed since my 1978 paper. Many more specimens are now available, among them the three new species described below. The taxonomy of the genus is based on the males, which have distinctive, species-specific genitalia and secondary sexual characters on the legs. Females are more difficult taxonomically but the additional material has allowed these to be tentatively keyed for the first time. Unfortunately, in the case of *T. josepheni,* I mis-associated the sexes in my original description, which has led to confusion over the identification of this species. The type material of all species except *T. collaris* and *T. undecimmaculatus* has been restudied.

The collections from which specimens were examined are listed under the following abbreviations:

ANIC Australian National Insect Collection, Canberra
NTM Northern Territory Museum and Art Gallery, Darwin
QM Queensland Museum, Brisbane
SAMA South Australian Museum, Adelaide
WAM Western Australian Museum, Perth
QDPIM Queensland Department of Primary Industries, Mareeba

Systematics

The genus *Tiporus* Watts belongs to that section of Australian Hydroporini with pseudotetramerous protarsi and densely rugose/punctate bodies including the legs. It can be distinguished from the other genera in this section, *Antiporus* Sharp and *Sekaliporus* Watts, by the form of the humeral angle of the elytron and the three-segmented protarsi in the male (see Watts 1997 for more details).

Within the genus there are two morphological groupings, one group characterised by: lack of pronotal ridges/grooves, moderate to strong dorsal colour pattern, a tendency for the edge of the elytron to bulge or extend outwards near the tip, protibia of the male with a small tubercle on the outside near the base, and the other group characterised by: pronotal ridges/grooves, dark colouring with only vague reddish patches, edges of the elytron serrated but not extended and the male protibia having a broad spine in the middle or towards the apex on the outside. To what degree these groupings reflect phylogenetic relationships has yet to be determined.

KEY TO *TIPORUS* WATTS

1 — Disc of pronotum with a ridge/groove running backwards parallel to and at a little distance from sides; edge of elytron serrated in apical half, never with lateral extension near tip; sides of pronotum dark, at most diffusely lighter in colour 7

— Disc of pronotum smooth, at most with weak ridges; edges of elytron usually smooth but often with rounded or triangular extension near tip; sides of pronotum usually with well-defined light coloured area 2

2 — Female with edge of elytron near apex with large, triangular extension reaching beyond tip of elytron (Fig. 8); male without such an extension, protibia with triangular spine on outside near middle .... *T. josepheni* (Watts)

— Both sexes with elytron with at most a modest bulge near tip or with the tip extended; males with small tubercle on outside of protibia at base 3

3 — Larger (4.5 mm long); postcoxal lines narrow, reaching metathorax; outer metatibial spine in male greatly elongated, about twice the length of the inner (Fig. 12); (female unknown) .... *T. moriartyensis* sp. nov.

— Smaller (< 4.1 mm long); postcoxal lines wide, often poorly defined towards front; outer metatibial spine in male normal, not greatly different in length to inner 4

4 — Female with tip of elytron clearly extended (Fig. 15); edge of pronotum weakly sinuate in front; male with metatibia expanded on inside near apex .... *T. tambreyi* (Watts)

— Tip of elytron not, or only weakly, extended (edge of elytron may be moderately expanded near, but not at, tip); sides of pronotum with only a hint of sinuation; male with normal metatibia 5

5 — Extreme front of elytron considerably narrower than adjacent pronotum, difference > width of mid segments of antenna (Fig. 4): lateral extension to elytron near tip absent or weak (Fig. 4); male with very long dagger-shaped proclaw (Fig. 7) ..... *T. georginae* sp. nov.

— Extreme front of elytron only slightly narrower than adjacent pronotum, difference <= width of mid segments of antenna; edge of elytron with moderate bulge near tip; males with either short stout proclaws or with moderately long but thin proclaws (Figs 13, 14) 6

6 — Pronotum weakly ridged at sides; edge of elytra straight immediately prior to it meeting pronotum; male proclaw short, thickened basally (Fig. 13) .... *T. denticularis* (Watts)

— Pronotum smooth; edge of elytra slightly curved immediately prior to it meeting pronotum; male proclaw elongate, thin (Fig. 14) ..... *T. centralis* (Watts)

7 — Large (> 5.0 mm long); male proclaw thick (Fig. 2), protibia stout, with basal spine (Fig. 3); apical segment of protarsi large, deeply bifid (Fig. 3); Pilbara region of W.A ..... *T. lachlani* sp. nov.

— Smaller (< 5.1 mm long); males not as above 8

8 — Tip of elytron with small but distinct point (except in some *T. alastairi*); elytral serrations usually strong; male protibia with prominent, triangular enlargement in apical half 9

— Tip of elytron rounded; elytral serrations weak; male protibia with small spine/tubercle on inside close to base .... *T. collaris* (Hope)

9 — Viewed laterally, the edge of elytra curves forward for short distance prior to meeting pronotum; male protibia with large triangular expansion on front edge near apex; male proclaw squat .... *T. alastairi* (Watts)

— Viewed laterally, the edge of elytra not, or only slightly, curved immediately prior to meeting lateral edge of pronotum; male protibia with small triangular expansion on front edge in middle or towards apex; male proclaw thin 10

10 — Male with tip of central lobe of aedeagus pointed (Fig. 20); protibia with triangular expansion just beyond centre .... *T. giuliani* (Watts)

— Male with tip of central lobe of aedeagus broad, weakly tridentate (Fig. 16); protibia with triangular expansion on front edge,

either in middle (N. Qld.) or towards apex (N.T., WA) .....
..... *T. undecimmaculatus* (Clark)

Tiporus georginae sp. nov.

Types

Holotype: male: 'W. Aust. Mitchell Plateau. 14°40'S 125°44'E 23 Sept 1982. B. V. Timms', dissected and mounted on card, SAMA.

Paratypes: 5, "14°52'S 125°50'E WA 'The Crusher' CALM Site 9/1 4 km S by W Mining Camp Mitchell Plateau 2–6 June 1988 I. D. Naumann", ANIC; 4, "14°25'S 126°40'E CALM Site 4/3 14 km S by E Kalumburu Mission W. A. 3–6 June 1988 T. A. Weir", ANIC (3), SAMA (1). All labelled as collected at light in open forest except for one in closed forest at CALM site 4/3.

Description Figs 4–7

Length 3.5 – 4.0 mm. Elongate-oval, wider in middle, front edge of elytron considerably narrower than rear edge of pronotum (Fig. 4). Pronotum smooth, without lateral ridges or grooves; edge of elytron turns forward sharply just before meeting edge of pronotum, very weakly serrate towards rear, usually slightly expanded near but not at tip, quite strongly acuminate. Whole body strongly rugose/punctate. Dorsal surface dark testaceous-black, front margin of head, sides and parts of front and rear margins of pronotum, three lateral spots and often some spots inwards from these on elytron, testaceous. Ventral surface dark testaceous-black, appendages including pro- and mesocoxae, much lighter. Pronotal process narrow, keeled, bluntly pointed. Metacoxal lines relatively close in hind half, widening to a bit more than two times their narrowest width in front quarter.

Male. Protarsi three-segmented, with adhesive setae ventrally, anterior parts of segments expanded, small spine on hind apical corner of second segment, third segment about 2.5 times length of second, single claw extremely long, expanded in middle (Fig. 6). Protibia with small tubercle on anterior edge at base (Fig. 7). Mesotarsi as for female. Metatibia with a slight thickening on inside near apex. Apical ventrite with small, sharp, apical keel/spine. Median lobe of aedeagus broad in centre, very narrow in apical quarter (Fig. 5).

Female. Protarsi five-segmented, first three moderately expanded with adhesive setae ventrally, apical segment cylindrical. Mesotarsi much narrower.

Remarks

Resembling *T. centralis* and *T. denticularis* in size and colour but with the mis-match of the humeral angle of the elytron and the posterolateral angle of the pronotum more noticeable (Fig. 4). Some specimens of *T. centralis* have this feature to a degree but the extremely long, dagger-like male proclaw in *T. georginae* (Figs 6, 7) readily separates male specimens from this and other *Tiporus*. The aedeagus is distinctive (Fig. 5). The species is known only from the Kimberley region where it is broadly sympatric with *T. centralis*.

Distribution

The Kimberley region of Western Australia.

Tiporus moriartyensis sp. nov.

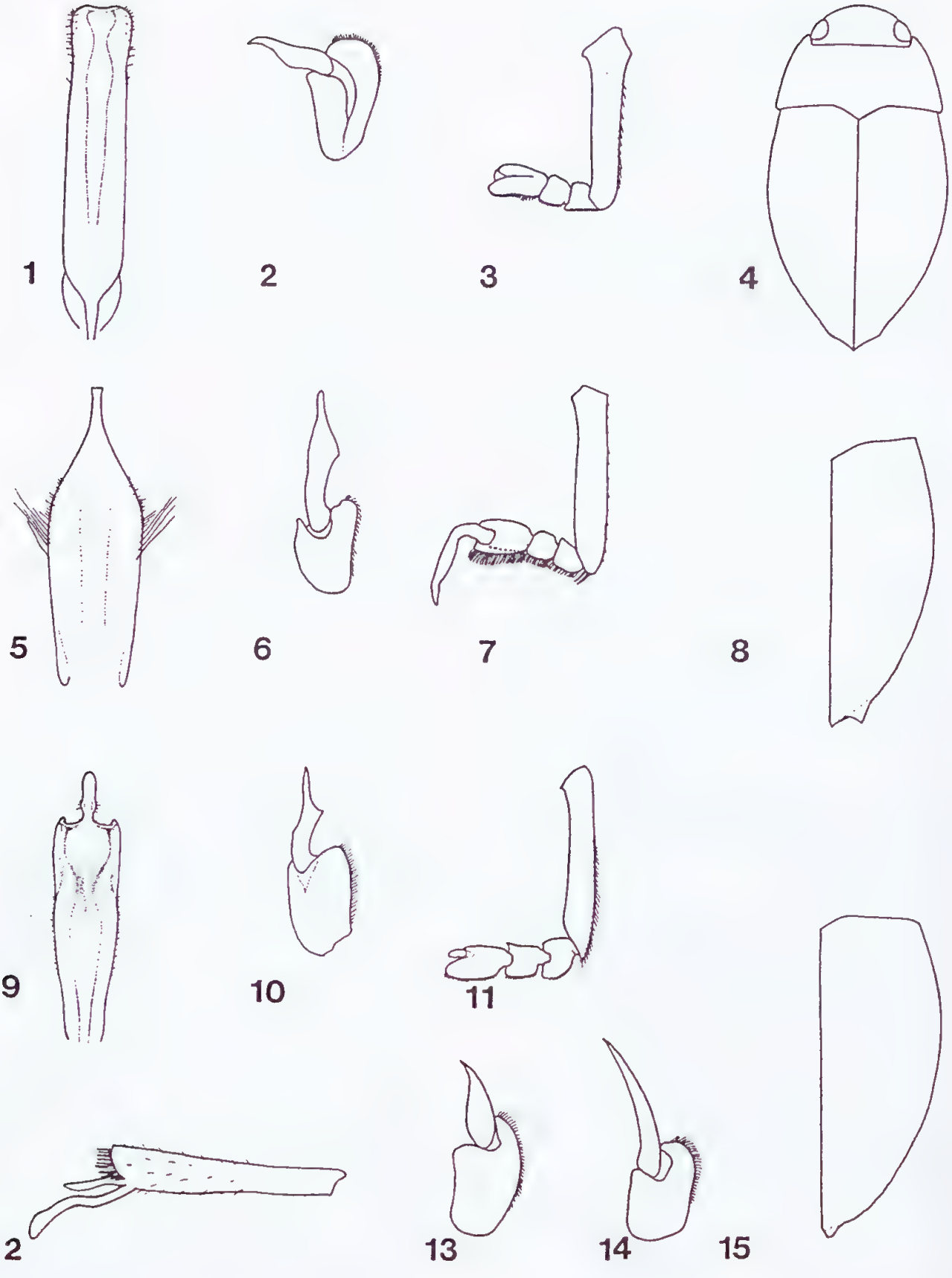
Types

Holotype: male, 'Moriarty ck N.T. Reardon 8/82', SAMA.

Description Figs 9–12

Length 4.5 mm. Elongate-oval, widest in middle. Pronotum narrower than elytra. Dorsal surface dark brown-black, rear of head, lateral margins and rear margin of pronotum, three small lateral spots and two larger spots near suture on elytron testaceous. Ventral surface mottled dark and light testaceous, appendages including pro- and mesocoxae much lighter. Whole body covered with rugose punctures, punctures smaller and less rugose than in other *Tiporus* species. Disc of pronotum smooth, without lateral ridges or grooves. Side of elytron curves forward immediately before meeting edge of pronotum, very weakly serrate towards tip, apex obliquely truncated. Pronotal process relatively broad, keeled, tip blunt. Metacoxal lines close, diverging to about two times their minimum width towards front, reaching mesosternum.

Male. Protarsi three segmented, segments expanded in front, with dense adhesive setae ventrally, second segment with small tooth on hind margin, apical segment 2.5 times length of second; claw short, rapidly narrowing to about half its width in middle (Fig. 10). Protibia with weak tubercle/spine near base on anterior edge. Metatibia with inner apical spine, twisted, flattened and broadened slightly at tip, about two



FIGURES 1–15. **1–3**, dorsal view of median lobe of aedeagus, apical view of proclaw and anterior view of protibia and tarsi of *T. lachlani*; **5–7**, ditto *T. georginae*; **9–11**, ditto *T. moriartyensis*; **4**, dorsal outline of *T. georginae*; **8**, dorsal outline of elytron of *T. josepheni*; **12**, metafemur of *T. moriartyensis*; **13**, apical view of proclaw and third tarsal segment of *T. denticulatus*; **14**, ditto *T. centralis*; **15**, dorsal outline of elytron of *T. tambreyi*.

times length of outer, which is simple (Fig. 12). Apex of last abdominal ventrite broadly depressed in middle, rear edge with two small spines in middle. Median lobe of aedeagus broad in middle, abruptly narrowing near apex (Fig. 9).

Female. Not known.

Remarks

Although only one specimen is available this is enough to show that *T. moriartyensis* is a very distinctive species. It belongs to the group of species lacking lateral pronotal ridges but is noticeably larger and less strongly punctured than other members. No other *Tiporus* has the inner apical spine on the metatibia modified as in this species. The female is unknown but it is likely that this character is restricted to the male.

Distribution

Known only from the type locality—Moriarty Creek, 160°4'S 129°12'E—in the Northern Territory.

Tiporus lachlani sp. nov.

Types

Holotype: male, 'Wooramel R. WA 25°47.52'S 115°17.44'E 26.8.94 S.A. Halse', SAMA.

Paratypes: 1, female, as for holotype, SAMA; 1, male, 'Gregory Gorge Fortescue R W.A. 2 xii.74 coll. K. F. Walker', SAMA.

Description Figs 1–3

Length 5.6 mm. Elongate-oval, widest behind middle, outline strongly indented at junction of pronotum and elytra. Lateral edge of elytra not curved forward immediately prior to meeting pronotum. Pronotum with well-developed lateral ridge/groove on each side, edge of elytron weakly serrated towards tip, tip weakly pointed. Dark testaceous, rear edge of head, lateral edges of pronotum, small patches at side of elytron near apex and appendages slightly lighter. Densely rugose/punctate throughout. Pronotal process narrow, keeled, bluntly pointed. Metacoxal lines raised, relatively wide apart, strongly diverging in anterior half to about 2.5 times their narrowest width, raised lines not reaching metasternum. Epipleuron evenly narrows until close to apex where it abruptly ends.

Male. Protarsi three-segmented, anterior portions greatly expanded and densely covered with adhesive setae ventrally, third segment as long as first two; claw shorter than third segment, squat, broad but narrowing to sharp point (Figs 2, 3). Protibia relatively short, thick, with strong tubercle on outside at base (Fig. 3). Apical ventrite with short well-marked keel near apex. Median lobe of aedeagus relatively narrow, parallel-sided (Fig. 1), ending in pick-like beak (not visible dorsally).

Female. Protarsi five-segmented, first three segments weakly expanded anteriorly, densely covered with adhesive setae ventrally, fourth segment very small, apical segment thin, cylindrical, shorter than third. Inner apical edge of metatarsal segments extended, extension accentuated by a number of strong spines.

Remarks

Tiporus lachlani differs from other *Tiporus* with ridged/grooved pronotum by its large size and strongly narrowed pronotal-elytral junction, as well as in male characters.

Distribution

The Pilbara/Gascoyne region of Western Australia.

Redescriptions Of The Other Species In The Genus, After Watts (1978) (Listed In Alphabetical Order)

Tiporus alastairi (Watts, 1978)

Description Fig. 23

Length 4.0 – 5.2 mm. Oval, convex. Dark red-brown, underside lighter. Strongly and densely rugose-punctate all over. Pronotum with a distinct raised ridge parallel to and a little distance inwards from each side, area just inside ridge depressed, ridge and depression strongest anteriorly, weak posteriorly. Elytron weakly margined, weakly serrated towards apex, usually sharply pointed (rounded in male holotype). Edge of elytron curves forward for short distance immediately prior to meeting edge of pronotum. Prothoracic process narrow, strongly convex, roundly pointed at apex, only slightly constricted between procoxae. Metacoxal lines strongly raised, well separated, quite strongly diverging in anterior two-thirds, not quite reaching mesosternum.

Male. Protarsus three-segmented. Anterior sides of segments of protarsus moderately expanded, a little expanded on mesotarsus. Single claw on

protarsus short, broad, weakly curved, dorsoventrally flattened, anterior edge deeply notched just beyond middle. Protibia with a large sharp tooth on outside just anterior to middle. Apical sternite strongly carinate for a short distance in middle near apex. See Fig. 23 for aedeagus.

Female. Protarsus five-segmented. Anterior sides of pro-and mesotarsi less expanded than in male. Apical abdominal sternite with a short sharp ridge in middle near apex.

Remarks

Females are difficult to separate from those of *T. undecimmaculatus* or *T. giuliani* but are larger than most specimens of these species and the edge of the elytron curves forward for a short distance immediately before it meets the edge of the pronotum whereas it is straight or almost so in *T. giuliani* and *T. undecimmaculatus*. The same applies to the males but in addition these have a much shorter and broader proclaw and a much narrower central lobe to the aedeagus than in these species. The species is so far known only from the north of Western Australia.

Distribution

Western Australia

2, Derby, SAMA; 3, 4 km W King Cascade, 15°38S 125°15'E, ANIC; 1, Kings Sound, ANIC.

Tiporus centralis (Watts, 1978)

Description Fig. 24

Length 3.2 – 3.9 mm. Oval, convex. Black; sides of pronotum and appendages reddish, sides and portions of middle of pronotum and base of elytron with vague red patches. Strongly and densely rugose-punctate throughout. Reticulate. Pronotum not flanged. Elytron with a weak shallow stria near the suture, edge curves forward slightly immediately before meeting pronotum, edge weakly to moderately expanded for a short distance near, but not at, tip which is pointed. Prothoracic process narrow, ridged in midline, apex rounded, weakly constricted between procoxae. Metacoxal lines strongly raised to metasternum, quite strongly divergent in anterior two-thirds.

Male. Protarsus three-segmented. Anterior sides of segments of protarsus moderately expanded, mesotarsus slightly expanded. Single claw on protarsus long, sharply curved near base, apical two-thirds straight. Protibia with a small tooth on outside near base. Tip of apical abdominal sternite broadly grooved in midline. See Fig. 24 for aedeagus

Female. Protarsi five-segmented; basal three segments of roughly similar size, weakly expanded anteriorly, ventral surface covered in adhesive setae; fourth segment very small; apical segment narrow, cylindrical, about same length as third segment; claws weakly developed.

Remarks

Tiporus centralis is very similar to *T. denticularis* and *T. georginae*—see discussion under those species.

Originally known only from the male holotype, the species is now known to be reasonably common in the Northern Territory and into Western Australia. It seems to have a more inland distribution than either *T. collaris* or *T. undecimmaculatus*, the other common Northern Territory species.

Distribution

Northern Territory

2, 46 km SSW Borroloola, ANIC; 1, 48 km SW by S Borroloola, ANIC; 3, 45 km W Borroloola, SAMA; 1, Davenport Ranges, 40 km NE Murray Downs Station, SAMA; 1, Elkedra Homestead, NTM; 6, Gosse River, Murchison Ranges, NTM; 2, Kakadu Highway, 31 km from Pine Creek, SAMA; 1, 35 mi N Larrimah, SAMA; 2, Moriarty Creek, SAMA; 1, Skull Creek (Victoria River), SAMA; 10, Victoria River, SAMA.

Western Australia

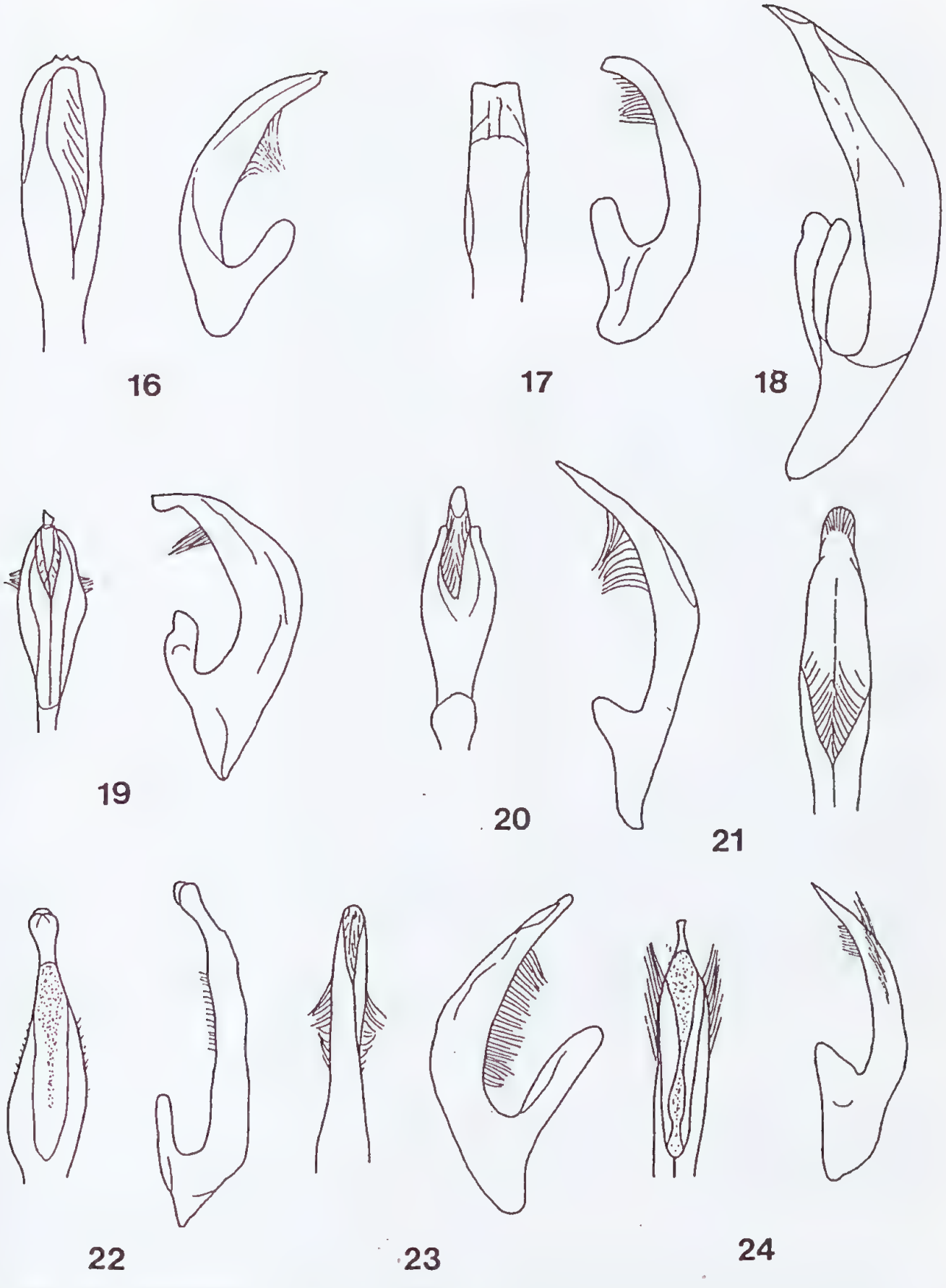
1, Stumpy Creek 'Glenroy', 16°55'S 125°34'E, SAMA.

Tiporus collaris (Hope, 1842)

Description Figs 18, 21

Length 3.3 – 4.1 mm. Oval, convex. Black; undersides and appendages a little lighter. Strongly and densely rugose-punctate all over. Reticulate. Pronotum widely flanged at sides, lacking raised ridges between disc and flange except very slightly anteriorly. Elytron weakly margined, moderately serrate towards apex which is rounded, base with vague longitudinal impressions. Prothoracic process narrow, strongly convex, roundly pointed at apex, not constricted between procoxae. Metacoxal lines raised, slightly to moderately diverging anteriorly.

Male. Protarsus three-segmented. Anterior sides



FIGURES 16–24. **16,** dorsal and lateral views of median lobe of aedeagus of *T. undecimmaculatus*; **17,** ditto *T. tambreyi*; **18,** ditto (lateral view) *T. collaris* (holotype); **19,** ditto *T. josepheni*; **20,** ditto *T. giuliani*; **21,** ditto (dorsal view) *T. collaris* (holotype); **22,** ditto *T. denticularis*; **23,** ditto *T. alastairi*; **24,** ditto *T. centralis*. From Watts (1978).

of segments of protarsus moderately expanded, those on mesotarsus a little expanded. Single claw on protarsus thick and curved, strongly toothed on underside near base. Protibia with a small tooth on outside near base. Tip of apical abdominal sternite moderately tuberculate in middle. See Figs 18, 21 for aedeagus.

Female. Protarsus five-segmented. Anterior sides of segments of protarsus a little less expanded than in male. Protarsus with two simple claws. Apical abdominal sternite simple.

Remarks

Tiporus collaris is very similar to *T. giuliani* and to *T. undecimmaculatus*. Males are readily distinguished from both these species by the basal position of the tubercle on the protibia rather than the central or more apical position in *T. giuliani* and *T. undecimmaculatus*. In addition, *T. collaris* is slightly more rounded, has slightly weaker pronotal ridges/grooves and has rounded rather than sharply pointed tips to the elytra.

The species occurs in small temporary streams in stony country across the north of the Northern Territory and Western Australia. Like *T. undecimmaculatus*, with which it is often collected, it appears to be more coastal than *T. centralis*.

Distribution

Northern Territory

8, 5 km SE Mt Borradaile, SAMA; 4, 6 km SE Mt Borradaile, SAMA; 1, 19 km E by S Mt Borradaile, ANIC; 1, Canon Hill, Kakadu National Park, SAMA; 1, Cooper Creek near Mt Borradaile, SAMA; 17, 1 km W Gubara, Kakadu National Park, SAMA; 1, 20 km SSW Jabiru, SAMA; 1, Kambolgie Creek, SAMA; 4, 10 km E by N Mt Cahill, ANIC; 1, Nawurlandja, Kakadu National Park, SAMA; 1, 6 km SW by S Oenpelli, SAMA.

Western Australia

1, Carson Escarpment, 14°49'S 126°49'E, ANIC; 1, Drysdale River, 15°02'S 126°55'E, ANIC; 2, Kimberley, SAMA; 4, Mitchell Plateau, 14°40'S 125°44'E, SAMA; 1, Upper Camp Creek, 14°49'S 125°51'E, SAMA.

Tiporus denticulatus (Watts, 1978)

Description Fig. 22

Length 3.4 – 3.6 mm. Oval, convex. Dark red-brown; sides, base and portions of anterior of pronotum, some small patches on elytron and appendages yellowish. Strongly and densely rugose-punctate throughout. Pronotum not flanged, with a weak ridge with deep groove on inside, parallel to and some distance inwards from sides. Apex of elytron pointed. Epipleuron with a small triangular expansion just before apex. Prothoracic process relatively broad, ridged in midline, apex rounded, moderately constricted between procoxae. Metacoxal lines straight in posterior half, rapidly diverging in anterior half, not reaching metasternum.

Male. Protarsus three-segmented. Anterior sides of segments of protarsus moderately expanded. Mesotarsus a little expanded. Single claw on protarsus short, flat, spindle-shaped, rapidly narrowing near apex on inside. Protibia with small tooth on outside near base. Tip of apical sternite with small weak ridge in midline. See Fig. 22 for aedeagus.

Female. Protarsus five-segmented, basal segments somewhat expanded on inside.

Remarks

Although the species has a weak ridge/groove on the side of the pronotum, the testaceous margin of the pronotum, smooth elytron edge, lateral expansion of the epipleuron near the tip and the basal position of the tubercle on the male protibia, ally it to the *T. josepheni* group of species. *Tiporus denticularis* is very similar to *T. centralis* and females are difficult to separate, but they differ from this species by the greater development of the pronotal ridge/groove and by the extreme front edge of the elytron immediately before it meets the edge of the pronotum being slightly curved in *T. centralis* but straight in *T. denticularis*.

Originally only known from the Cairns-Cooktown region of North Queensland the additional specimens extend its known range into the Northern Territory.

Distribution

Queensland

1, 34 km NW Chillagoe, SAMA; 8, 70 km SW Greenvale, SAMA; 7, Lakeland Downs, SAMA; 3, Laura, SAMA; 4, Mary Creek, 16°33'S 12°5'E, ANIC; 2, 11 km WSW Petford, QDPIM; 2, Walsh River near Chillagoe, QDPIM; 1, Windsor Tableland, QDPIM.

Northern Territory

1, Bullita Outstation, 16°07'S 130°25'E, NTM; 1, Victoria River, SAMA.

Tiporus giuliani (Watts, 1978)

Description Fig. 20

Length 3.6 – 4.2 mm. Oval, convex. Black; appendages, some vague reddish areas at base of pronotum and base and sides of elytron, lighter. Moderately strongly rugose-punctate throughout. Pronotum with a raised ridge parallel to and a little distant inwards from each side, area just inside ridge depressed, ridge and depression strongest anteriorly, weak posteriorly. Elytron weakly serrated towards apex which is pointed. Prothoracic process narrow, strongly convex, bluntly pointed at apex, only slightly constricted between procoxae. Metacoxal lines relatively close, strongly diverging in central third, weakly in anterior and posterior third, reaching metasternum.

Male. Protarsus three-segmented. Anterior sides of segments of protarsus moderately expanded, weakly so on mesotarsus. Single claw on protarsus short, narrow, with slight notch on underside in middle. Protibia moderately strongly toothed on outside in middle. Apical sternite strongly carinate for a short distance in middle near apex. See Fig. 20 for aedeagus.

Female. Protarsus five-segmented. Pro- and mesotarsi less expanded than in male. Apical abdominal sternite very weakly carinate in middle near apex.

Remarks

Tiporus giuliani is close to *T. undecimmaculatus* and *T. collaris*. It can be separated from *T. collaris* by its stronger pronotal ridges/grooves, sharply pointed elytral tips, stronger colour pattern and the central position of the spine on the male protibia.

The only clear separation from *T. undecimmaculatus* is the shape of the tip of the median lobe of the aedeagus which is broad with three small spines at the tip in *T. undecimmaculatus* (Fig. 16) and narrow and bluntly pointed in *T. giuliani* (Fig. 20). In the Northern Territory and Western Australia the more apical position of the spine on the male protibia and the more pronounced dorsal colour pattern will separate it from *T. undecimmaculatus*. However specimens of *T. undecimmaculatus* from Queensland resemble *T. giuliani* both in the central position of the spine on the male protibia and in the well developed dorsal colour pattern.

A less common species than some and possibly more inland than coastal in distribution.

Distribution

Northern Territory

4, Kakadu Highway, 31 km from Pine Creek, SAMA.

Western Australia

1, Beverley Springs, WAM; 2, Duncan Highway, WAM; 2, near Dampier Downs, WAM; 4, Logues Springs, 102 km SE by E Broome, ANIC; 1, 163 km SE by S Broome, ANIC.

Tiporus josepheni (Watts, 1978).

Description Figs 8, 19

Length 3.5 – 4.1 mm. Oval, convex. Black, sides of pronotum narrowly vaguely reddish, appendages dark red-brown. Ventral surface moderately and densely rugose-punctate, dorsal surface closely and moderately punctate. Pronotum not laterally flanged or ridged. Tip of elytron weakly pointed. Prothoracic process narrow, strongly convex, only slightly constricted between procoxae, apex rounded, midline virtually impunctate. Metacoxal lines well separated, moderately diverging posteriorly and in middle, subparallel in anterior quarter, reaching metasternum.

Male. Protarsus three-segmented. Anterior sides of segments of protarsus strongly expanded. Mesotarsus a little expanded. Single claw on protarsus short, flat, narrowing abruptly on inside near apex, base with a large rounded expansion beneath. Protibia with small tooth on outside in middle. Tip of apical sternite depressed slightly in midline. See Fig. 19 for aedeagus.

Female. Protarsus five-segmented, robust, basal segments somewhat expanded on inside. Elytron with very well developed lateral subapical spine (Fig. 8).

Remarks

Originally described from Beverley Springs and Wittenoom Gorge in the Kimberley and Pilbarra regions of Western Australia respectively, the species is now known to be much more widespread, occurring right across coastal Northern Australia. It is particularly common in North Queensland. It seems to favour larger and more permanent rivers than other *Tiporus*.

Unfortunately I mis-associated the sexes in my original description. (The female paratype in ANIC belongs to *T. tambreyi*.)

Distribution

Northern Territory

2, Cooper Creek near Mt Borradaile, SAMA; 7, Magela Creek, SAMA; 2, Magela Creek, 12 km E Jabiru, SAMA; 1, Nourlangie Creek, 20 km SSW Jabiru, SAMA.

Queensland

1, Barron River, QDPIM; 52, 8 km N Bluewater, SAMA; 1, 25 km N Coen, SAMA; 2, 2 km NW Daintree, QDPIM; 2, Emu Creek 5 km W Petford, QDPIM; 8, Eubenangee Swamp near Babinda, SAMA; 2, Helenvale, SAMA; 18, Lakeland Downs, SAMA; 1, Laura, SAMA; 2, Mazlin Creek Atherton area, QDPIM; 1, 2 km S Mt Molloy, SAMA; 2, 20 km S Townsville, SAMA; 1, 37 km S Townsville, SAMA; 7, Walsh River 34 km NW Chillagoe, SAMA.

Western Australia

1, Beverley Springs, WAM; 1, Stumpy Creek 'Glenroy' 16°55'S 125°34'E, SAMA.

Tiporus tambreyi (Watts, 1978)

Description Fig. 17

Length 3.5 – 4.4 mm. Oblong oval, strongly convex, pronotum a little constricted in anterior quarter. Black, extreme anterior of head, sides of pronotum narrowly, a basal spot and extreme lateral markings on elytron and appendages reddish. Moderately strongly and very densely punctate all over, punctures on pronotum and elytron with short setae. Reticulation strongest anteriorly. Pronotum and elytron weakly margined, margins of elytron weakly serrated towards apex, extreme apex not margined. Prothoracic process lanceolate, quite strongly expanded behind procoxae, narrow between procoxae, weakly flanged, strongly carinate. Metacoxal lines strongly raised, rapidly diverging in anterior half, subparallel posteriorly.

Male. Anterior sides of segments of protarsus moderately expanded, posterior sides unexpanded. Basal segment of mesotarsus weakly expanded. Single claw of protarsus greatly expanded in basal half, flattened dorsoventrally. Metafemur robust, curved. Metatibia angularly thickened on inside near apex. Protibia with a small tooth on outside close to base. Last abdominal sternite widely and weakly grooved in midline with a small knob in middle of groove at extreme apex, edges of sternite at apex raised for some distance either side of groove. See Fig.17 for aedeagus.

Female. Smaller, more densely punctate. Protarsus asymmetrically expanded as in male but not to same extent. With small triangular extension at tip of elytron, diverging from each other when elytra closed (Fig. 15).

Remarks

A relatively large species known only from the Pilbara region of Western Australia, readily distinguished from all other *Tiporus* by the expanded male metatibia and the triangularly extended elytral tips in the female. The sides of the pronotum straighten slightly in front giving the pronotum a slightly sinuate outline.

Distribution

Western Australia

1, 17 km N by E Cane River Homestead, ANIC; 15, Gregory Gorge, Fortescue River, SAMA; 16, Millstream, ANIC; 1, Millstream, Palm Pool area, WAM; 9, 1 km N Millstream, ANIC; 4, 3 km NW by W Millstream, ANIC; 1, Tambrey, WAM; 1, Wittenoom Gorge, ANIC.

Tiporus undecimmaculatus (Clark, 1862)

Description Fig. 16

Length 3.4 – 4.6 mm. Oval, convex. Black or dark red-brown; underside and appendages a little lighter, base of pronotum and sides of elytron with vague red patches in many. Strongly and densely rugose-punctate all over. Reticulate. Pronotum with a distinct raised ridge parallel to and a little distance from each side, area just inside ridge depressed, ridge and depression strongest anteriorly, weak posteriorly. Elytron weakly margined, strongly convex, rounded towards apex which is pointed. Prothoracic process narrow, strongly convex, roundly pointed at apex, little if at all constricted between procoxae. Metacoxal lines raised, slightly to moderately diverging anteriorly.

Male. Anterior sides of segments of protarsus moderately expanded, those on mesotarsus a little expanded. Single claw on protarsus weakly curved, slightly thickened and with a small tooth on underside near base and another just before the middle. Protibia with a small sharp tooth on outside in apical half. Tip of apical abdominal sternite weakly to strongly tuberculate in middle. See Fig. 16 for aedeagus.

Female. Anterior sides of segments of protarsus

a little less expanded than in the male. Protarsus with two simple claws. Apical abdominal sternite simple or slightly tuberculate at tip.

Remarks

Tiporus undecimmaculatus is a widespread and variable species very similar to *T. collaris* and *T. giuliani*—see notes under those species. Two forms are distinguishable. The nominal form, from the Northern Territory and Western Australia, is usually dark with the dorsal colour pattern subdued or absent and has the spine on the male protibia towards the apex. The other form, from north Queensland, has a well-developed dorsal colour pattern, the spine on the male protibia close to the centre of the protibia, the central lobe of the aedeagus a bit broader and also tends to be larger.

Tiporus undecimmaculatus is common in small temporary streams in stony country in coastal areas across Northern Australia in similar habitats to *T. collaris* but is usually more abundant than that species. A more coastal species than *T. centralis*.

Distribution

Western Australia

1, Bigge Island, 14°29'S 125°10'E. SAMA; 7, Careening Bay, 15°06S 125°00E, SAMA; 9, Carson Escarpment, 14°49'S 126°49'E, ANIC; 1, Cave Spring, 15°32'S 128°50'E, WAM, ANIC; 1, Duncan Highway, WAM; 3, 14 km S by E Kalumburu Mission, ANIC; 2, 4 km W King Cascade, 15°38'S 125°15'E, ANIC; 3, 4 km S by W Mining Camp, Mitchell Plateau, 14°52'S 125°50'E, ANIC; 7, Mitchell Plateau, 14°40'S 12°44'E, SAMA.

Northern Territory

3, 6 km SE Mt Borradaile, SAMA; 6, 19 km E by S Mt Borradaile, ANIC, NTM; 137, 5 km SE Mt Borradaile, SAMA; 2, Bukkita outstation, 16°07'S 130°25'E, NTM; 1, 7 km NW by N Cahills Crossing, Kakadu National Park, SAMA; 1, Canon Hill, Kakadu National Park, SAMA; 1, 4 mi S Coolibah, WAM; 3, Gosse River, Murchison Ranges, NTM; 13, 1 km W Gubara, Kakadu National Park, SAMA; 2, Kambolgie Creek, SAMA; 2, Magela Creek, SAMA; 2, 19 km E by N Mt Cahill, ANIC; 5, 10 km E by N Mt Cahill, ANIC; 1, 15 km E by N Mt Cahill, ANIC; 15, 40 km NE Murray Downs Station, SAMA; 4, 6 km SW by S Oenpelli, ANIC, SAMA; 5, Nawurlandja, Kakadu National Park, SAMA; 1, Nourlangie Creek, 20 km S Jabiru SAMA.

Queensland

2, Cairns, SAMA; 1, Charters Towers, SAMA; 1, 25 km N Coen, SAMA; 1, Helenvale, SAMA; 15, 14 km W Herberton, SAMA; 21, Lakeland Downs, SAMA; 4, Laura, SAMA; 1, 12 km N Laura, SAMA; 1, McIlwraith Ranges Weather Station, SAMA; 1, 17 km up Mt Lewis Road, QDPIM; 6, Mt Spec, ANIC; 8, 10 mi W Paluma, SAMA; 1, 20 km W Petford, SAMA; 8, 15 km W Petford, QDPIM.

Acknowledgments

The curators of the collections listed earlier are thanked for allowing me to examine specimens in their care. The illustrations were most ably done by Mr R. Gutteridge and Ms Debbie Churches helped finalise the manuscript. All are thanked for their support and help.

References

WATTS, C. H. S. 1978. A revision of the Australian Dytiscidae (Coleoptera). *Australian Journal of Zoology, Supplementary series* No 57: 1–166.

WATTS, C. H. S. 1985. A faunal assessment of Australian Hydradephaga. *Proceedings of the Academy of Natural Sciences Philadelphia* **137**: 22–28.

WATTS, C. H. S. 1997. A new genus and species of Australian Dytiscidae (Coleoptera). *Records of the South Australian Museum* **29**: 121–123

THE *PARACYMUS* OF AUSTRALIA (COLEOPTERA, HYDROPHILIDAE)

ELIO GENTILI

GENTILI, E. 2000. The *Paracymus* of Australia (Coleoptera, Hydrophilidae). *Records of the South Australian Museum* **33**(2): 101–122.

The described Australian *Paracymus* were hitherto placed in six species. Of these three are to be considered synonyms of *P. pygmaeus* (MacLeay, 1871): *nitidiusculus* (Broun, 1880), *metallescens* Fauvel, 1883, and *desolatus* Wooldridge, 1976 (new synonymy). To the remaining valid species *P. pygmaeus* (MacLeay, 1871), *spenceri* Blackburn, 1896, and *gigas* Gentili, 1996 another six new species are now added: *P. cariceti, wattsi, opacus, australiae, weiri,* and *ovum.* Lectotypes are designated for *P. pygmaeus, nitidiusculus,* and *metallescens.* Each valid species is described, discussed, mapped (with a detailed list of localities), figured (aedeagi, outlines) and keyed.

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Introduction

This work is intended to continue on with the project of A. F. Newton and M. K. Thayer to improve our knowledge of the Staphyliniformia of Australia. After the studies on the hydrophilid genera *Notohydrus* (Gentili 1992) and *Paranacaena* (Gentili 1993) the genus *Paracymus* Thomson, 1867 is now considered.

Hansen (1991) placed *Paracymus* in the tribe Anacaenini, giving a description of the genus. The features basically characterising *Paracymus* among Anacaenini appear to be the prosternum longitudinally carinate and the presence of a sutural stria on the elytra (see also d'Orchymont 1942).

Gentili (1993) dealt with the nine Australian taxa treated in the literature under the genus *Paracymus*, placing four of them (*lindi* Blackburn, 1888, *sublineatus* Blackburn, 1888, *horni* Blackburn, 1896, and *eremita* Blackburn, 1896) in *Paranacaena* Blackburn, 1888 and one (*nigerrimus* Blackburn, 1891) in *Chaetarthria* Stephens, 1835, leaving in *Paracymus* the remaining four (*pygmaeus* McLeay, 1871, *nitidiusculus* Broun, 1880, *spenceri* Blackburn, 1896, and *desolatus* Wooldridge, 1976). Four other taxa might be added to the list: *Paracymus phalacroides* (Wollaston, 1867); Wooldridge 1978 wrote: 'two females from Australia seem to belong here. If these...specimens are really *P. phalacroides*, they probably are the result of accidental introduction, because they do not seem to be established in...the country'; *Paracymus metallescens* Fauvel, 1883 from New Caledonia; *Anacaena tepida* Winterbourn, 1970 treated as *Paracymus* in a manuscript of R. Ordish on New Zealand Hydrophilidae, and *Paracymus gigas* Gentili, 1996.

Material And Methods

More than 6 000 specimens were studied from the Institutes and Museums listed below under 'Acronyms', nearly 5 000 of them belonging to the Australian National Insect Collection. Specimens were examined with a Beck Kassel CBS stereoscopic microscope; the figured aedeagi were mounted in di-methyl-hydanthoin-formaldehyde (DMHF) on transparent plastic card, studied and drawn with a GALILEO LG transmitted light microscope equipped with a projection device.

Acronyms

AMS – Australian Museum, Sydney.
ANIC – Australian National Insect Collection, CSIRO, Canberra.
CASF – California Academy of Sciences, San Francisco.
FMNH – Field Museum Natural History, Chicago.
ISNB – Institut Royal des Sciences Naturelles de Belgique, Bruxelles.
MSNV – Museo Civico di Storia Naturale, Verona.
NHML – Natural History Museum, London.
NMW – Naturhistorisches Museum, Wien.
SAMA – South Australian Museum, Adelaide.
USNM – United States National Museum, Washington.

Descriptions

Each valid Australian species is discussed below according to the following scheme: (1) References; the dates of description and of the quoted papers conform to Hansen (1999). (2) Type material; I searched for the available types of the described taxa (valid species and synonyms), designating lectotypes and paralectotypes where necessary. (3) Description; many characters are considered: measures, outline, upperside, underside, palps, antennae, legs and aedeagus. (4) Discussion; the species are compared with other similar species or with the proposed synonyms. (5) Material examined; the States of the Australian continent are listed alphabetically; the localities within each State are also listed alphabetically. (6) Biology; the biological notes are derived from the label data.

1. *Paracymus pygmaeus* (MacLeay, 1871)

Cyclonotum pygmaeum MacLeay, 1871: 133; White in Masters, 1871: 5.

Coelostoma pygmaeum (MacLeay): Zaitzev 1908, 404.

Paracymus pygmaeus (MacLeay): Blackburn 1888: 820; 1894: 203; Knisch 1924: 167; d'Orchymont 1937: 154, 157; McKeown 1948: 99; Wooldridge 1976: 459–461; Matthews 1982: 55; Hansen 1999: 113.

Hydrobius nitidiusculus Broun, 1880: 78.

Paracymus nitidiusculus (Broun): Sharp 1884: 467; Blackburn 1888: 820–821.

Paracymus metallescens Fauvel, 1883: 352; Knisch 1924: 166; d'Orchymont 1926: 376 (? synonym of *pygmaeus*).

Paracymus desolatus Wooldridge, 1976: 458–459; Hansen 1999: 110. New synonymy.

Types

Lectotype male (1.7 x 1.3 mm): **Queensland**: Gayndah, W. McLeay, 1871, ANIC. A single pin bears the following cards or labels: 1. insect and its abdomen; 2. aedeagus and spiculum gastrale in DMHF; 3. Round amaranth label; 4. Gayndah; 5. Cyclonotum pygmaeum, Macl. Gayndah (by hand); 6. On permanent loan from Macleay Museum University of Sydney; 7. Syntype (red label); 8. Lectotype male designated by E. Gentili 1991 (red label); 9. Lectotype male Cyclonotum pygmaeus Macl. Det. R. G. Ordish. *Paralectotypes*: **Queensland**: Gayndah, W. McLeay 1871 (4), ANIC, AMS. The previously mentioned manuscript of R. G. Ordish says: 'For access to syntypes I am indebted to Mr T. A. Weir, CSIRO Canberra and to Dr G. A. Holloway of the Australian Museum, Sydney. I am advised that the material collected from Gayndah was shared between the Macleay Museum and the Australian Museum and that a specimen in the latter has subsequently been labelled as the Holotype, seemingly on the basis of an original name label (McKeown 1948). As the writer points out, 'types in the Macleay Museum collection are not specially indicated as such'. Validity aside, there are two obstacles to this recognition of a holotype. Firstly, all three mounts bear original determination labels in Macleay's hand, and secondly the mount bearing the holotype label (K 19573) has two specimens on it. There are five syntypes from which a subsequent author could choose a lectotype and I have done this by selecting the best preserved male'. The manuscript of Ordish was not published, but his work is so reliable that I follow his statements, designating as lectotype the specimen chosen by him, seen also by me by courtesy of T. A. Weir.

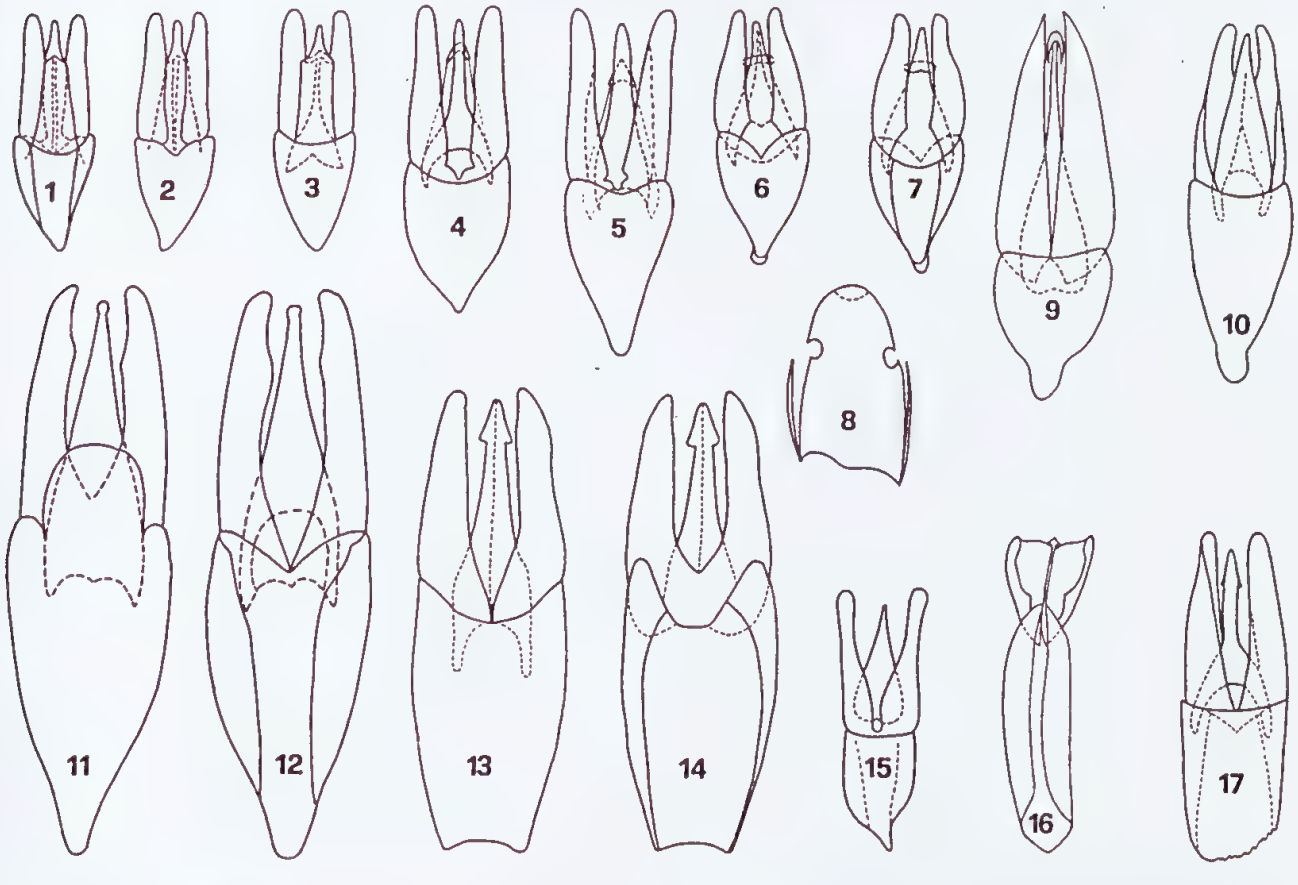
Synonyms

(1) *Hydrobius nitidiusculus* Broun, 1880. *Lectotype* female: **New Zealand**, Tairua, Broun 1880, NHML. A single pin bears the following cards and labels: 1. Insect; 2. 144; 3. Type (Circular label red-bordered); 4. Tairua; 5. New Zealand, Broun Coll., Brit. Mus. 1922-182; 6. *Paracymus nitidiusculus*; 7. female Lectotypus, *Hydrobius nitidiusculus* Broun, E. Gentili 1992 (red label). I did not see other types, but Broun certainly described the species based on more specimens, as in the description he states: 'I obtained the specimens now before me at Tairua and Whangarei Heads'. Blackburn (1888) wrote: 'Appears to be common in South Australia... I have taken it in Western Victoria also'. But in 1894 he wrote: '*Paracymus (Cyclonotum) pygmaeus*, Macl. I have recently received examples (compared with the type) of this insect from Mr. Lea. They seem certainly identical with *Paracymus (Hydrobius) nitidiusculus*, Brown. Macleay's is the older name'. After examination of the type, I agree with Blackburn.

(2) *Paracymus metallescens* Fauvel, 1883. *Lectotype* male (2.2 x 1.2 mm): **New Caledonia**, Tonghoué, Savès, ISNB. A single pin bears the following cards and labels: 1. Insect and its abdomen; 2. Aedeagus in DMHF; 3. Coll.

R.I.Sc.N.B., Nouvelle Calédonie, Tonghoué 9me, Rec. Savès, ex Coll. Fauvel (pink card); 4. Coll. et det. A. Fauvel, *Paracymus metallescens* Fvl., R.I.Sc.N.B. 17.479; 5. Syntype; 6. Lectotypus male, *Paracymus metallescens* Fauv., E. Gentili 1991. Three *paralectotypes* are also present in the ISNB, from the following localities: 1) Marais de l'anse Vata, juilliet 8me, Nouméa, Rec. Savès; 2) Kanala, Rec. Coste; 3) Koné, Rec. Atkinson. Fauvel (1883) wrote: 'Aussi en Australie'; and d'Orchymont 1926 stated: '*Paracymus metallescens* Fauvel, 1883 from New Caledonia is perhaps the same as *P. pygmaeus* W. S. MacLeay, 1871, from Australia, but no material from the original country could be seen'. Comparison with the Australian insects, including the aedeagus (Fig. 3), leads me to synonymise the two taxa.

(3) *Paracymus desolatus* Wooldridge, 1976. *Holotype* male (2.1 x 1.2 mm): **Western Australia**, Winjana Gorge, Ross & Cavagnaro 17.10.1962, CASF. A single pin bears the following cards and labels: 1. Insect with semiextracted aedeagus; 2. W. Australia: Winjana Gorge 100 m X.17.62; 3. Collectors E. S. Ross D. Cavagnaro; 4. male; 5. HOLOTYPE *Paracymus desolatus* Wooldridge (red label); 6. California Academy of Sciences Type No. 12007. *Paratypes*: the description quotes 143 males 149 females (including the allotype) from Northern Territory, Queensland, Western Australia, housed in CASF, NHML, SAMA, USNM. I here synonymise *P. desolatus* with *P. pygmaeus* after a long effort to isolate the true characteristics of *desolatus*. These might be: 1) pronotal punctation fine and widely separate, elytral punctation closer and more impressed; in *pygmaeus* pronotal and elytral



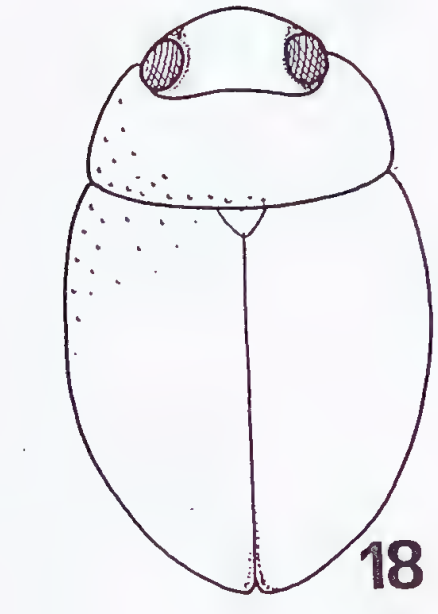
FIGURES 1–17. Aedeagi. **1**, *Paracymus pygmaeus* (MacLeay, 1871), lectotype, dorsal view; **2**, Idem, ventral view; **3**, *Paracymus metallescens* Fauvel, 1883, lectotype, ventral view; **4**, *Paracymus pygmaeus* (Kosciusko NP) showing the preapical collar and the connected membrane; **5**, *Paracymus pygmaeus* (Warburton): as in Fig. 4; **6**, *Paracymus spenceri* Blackburn, 1896, lectotype, ventral view; **7**, Idem, dorsal view; **8**, Idem, spiculum gastrale; **9**, *Paracymus cariceti* n. sp., holotype, ventral view; **10**, *Paracymus australiae* n. sp., holotype, ventral view; **11**, *Paracymus gigas* Gentili, 1996, holotype, ventral view; **12**, Idem, dorsal view; **13**, *Paracymus weiri* n. sp., holotype, ventral view; **14**, Idem, dorsal view; **15**; *Paracymus wattsi* n. sp., holotype, ventral view; **16**, *Paracymus opacus* n. sp., holotype, dorsal view; **17**, *Paracymus ovum* n. sp., holotype, ventral view.

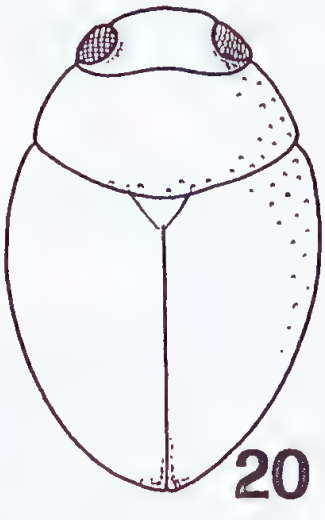
punctation nearly equal. This character is conspicuous at 100 x but in a great number of sympatric specimens presents a high variability, from insects nearly impunctate to coarsely punctate on the whole dorsal surface; 2) the last segment of male protarsi less widened and hooked than in *pygmaeus*. I examined the holotype but was not able to distinguish the pattern of its protarsi from that of *pygmaeus*; 3) the mesofemora pubescent only on basal triangle, covering only 1/3 of anterior edge; in *pygmaeus* more pubescent, covering nearly 1/2 of anterior edge. In many cases this distinction is in my opinion impossible to see; 4) penis rapidly narrowing and becoming parallel-sided for about one-third its length; narrowly triangular in *pygmaeus*. Really the penis is narrowly triangular, due to a membranous expansion, from the base to a preapical collar in both forms. Sometimes the membranous expansion is scarcely visible or contracted, possibly due to effects of preservation.

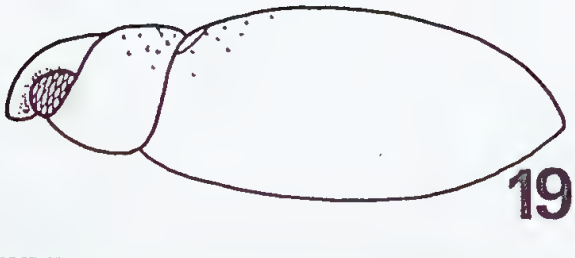
(4) *Anacaena tepida* Winterbourn, 1970 is treated as a synonym of *P. pygmaeus* by R. Ordish in the above mentioned manuscript. But no author records it from Australia. Therefore I think it is not necessary to treat this species here.

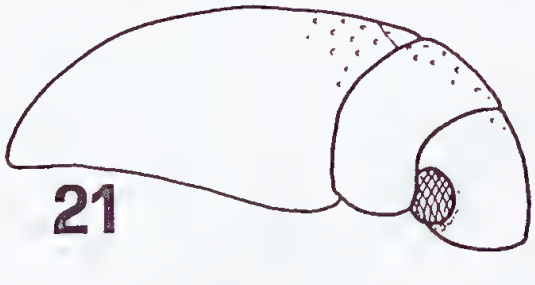
Description

Length 1.6–3.0 mm; width 0.9–1.6 mm. Elongate oval, slightly convex (Figs 18, 19). Head black, evenly punctured, surface shining between punctures, occipital region alutaceous; transverse sutures distinct, coronal suture obsolete. Pronotum dark, a little paler at sides, black to reddish-brown, with olive-green reflections in some specimens; punctation finer than on head, obvious at sides, faint or absent on disc. Elytra uniform black to reddish-brown, with green reflections in some specimens, shining between punctures, punctures shallow like those of pronotum or shallower, but evenly distributed, with sparse setae laterally; parasutural furrow









FIGURES 18–21. **18**, Outline of *Paracymus pygmaeus* (MacLeay, 1871); **19**, Profile of *Paracymus pygmaeus*; **20**, Outline of *Paracymus wattsi* n. sp.; **21**, Profile of *Paracymus opacus* n. sp.

extended from apex nearly to anterior third of elytra. Under side dark; prosternum broadly keeled in middle and with a projection on anterior border; mesosternum with transverse ridge, a median keel anterior and posterior to it extending to both borders. First visible (third) abdominal ventrite with a median keel throughout its length. Palps pale yellow except for darkened apices; antennae pale yellow, eight-segmented. Profemur ventrally pubescent on proximal third; male protarsus with last segment shorter and broader than in female with two short, ventral, blunt spines; tarsal segments 1–4 (male protarsus) with a single ventral spine; protarsal claws of male less evenly curved than in female but equal in length. Ventral pubescence of mesofemur confined to proximal half or third and not reaching posterior border. Metafemur glabrous with weak longitudinal scratch-like impressions. Aedeagus (Figs 1–5) with tegmen pointed at base, parameres blunt at apex and scarcely longer than tegmen. Penis blunt at apex, with a collar at beginning of the apical third; from collar a membranous expansion reaches base of parameres describing a triangle; sometimes this expansion is scarcely conspicuous, possibly due to the methods of preservation (e.g. ethyl alcohol). Gonopore subapical and ventral.

Discussion

This is the most widespread *Paracymus* in Australia. Some of its characters, such as the dorsal punctation and the extension of the hairy surface on the mesofemora, show great variability. It is easy to separate from other species by the shape of its aedeagus: tegmen pointed at base (difference from *weiri* and *ovum*), scarcely shorter than parameres (difference from *opacus*, *gigas*, *weiri*, *australiae*, *cariceti*); penis simply pointed (difference from *cariceti*, *opacus*, *gigas*), with a preapical collar (as in *spenceri*, but the collar of *spenceri* lacks the membranous expansion). Other distinctive characters are the last protarsal segment of males, which is broader than in any other Australian *Paracymus*, and the scarce pubescence of the profemora.

Material examined (Fig. 22)

Australian Capital Territory: Black Mt., I. F. B. Common 12.11.1964 (1), 16.11.64 (4), 22–26.12.64 (1), 6.1.65 (1), 14.11.65 (1), 14.12.65 (6), 20.12.65 (6), 29.12.65 (9), 6.1.66 (2), 10.1.66 (2), 11.1.66 (2), 18.1.66 (1), 20.1.66 (1), 17.3.66 (2), 21.3.66 (2), 22.3.66 (1), light trap, ANIC; Black Mt., M. S. Upton 15.10.1965 (7), 8.12.65 (1), 15.12.65 (3), 16.12.65 (1), 22.12.66 (3), 24.1.67 (6), 16.10.67 (2), 30.11.67 (1), 12.12.67 (1), 10.1.68 (2),14.1.68 (1), 17.1.68 (2), 29.1.68 (1), 1.2.68 (2), 2.2.68 (1), 13.2.68 (2), 28.2.68 (1), 4.3.68 (1), 25.3.68 (2), 26.3.68 (5), 27.3.68 (2), 28.3.68 (3), 29.3.68 (3), 12–16.4.68 (1), 22.4.68 (1), light trap, ANIC; Black Mt., Z. Liepa 20.5.1966, ex rotting wood in creek (1); Black Mt., E. B. Britton 25.11.1964 (1) at light, ANIC; Black Mtn Reserve, S. Misko 4.12.1970 (2) light trap, ANIC; Black Mt. 600 m, 35°16'S 149°06'E, Weir Dressler & Lawrence 12.1986 (1) flight intercept window/trough trap, ANIC; Black Mt., Bywater & Clayton 23.1.1967 (1) from nest of Buff-tailed Thornbill, ANIC; Canberra, H. & A. Howden 2–3.XII.1986 (1) black light, ANIC; Cotter River, E. J. Pook 20.12.1965 (5) ANIC; Lake Burley Griffin, Z. Liepa 19.11.1965 (1) ANIC; Narrabundah Orchard, 21.11.1966 (1) ANIC; Paddy's River 1 mi S of Cotter Dam, S. Misko 17.4.1969 (2) ANIC; Piccadilly Circus 1240 m, 35°22'S 148°48'E, Lawrence Weir & Johnson 5.1984, 9.84, 12.84 (6) flight intercept window/trough trap ANIC; Piccadilly Circus, C. Reid 10.12.1984 (1) powerline clearing, ANIC; Piccadilly Circus 6 km NE, Wombat Ck, 35°19'S 148°47'E, 750 m, Weir Lawrence & Johnson 8. 1985 (1) flight intercept window/trough trap, ANIC; Snowy Flat Ck, Mt Gingera 0.5 km NE, 35°35'S 148°47'E, A. A. Calder 28.6.1988, ANIC. **New South Wales**: Albury, E. F. Riek 26.1.1963 (2) ANIC; Araluen, Apple Tree Ck, W. & S. Allen 6.12.1975 (1) ANIC; Berry, C. Watts 1.1967 (2) SAMA; Blue Mountains, Foulcon Bridge, 500 m, G. Wewalka 15.1.1993 (8) NMW, MSNV; Blue Mts, H .J. Cox (2) ANIC; Braidwood 15 km NW, Shoalhaven R., C. Reid 19.12.1984 (1) on Acacia spp., ANIC; Broken Head Nat. Reserve, Byron Bay 8 km S, Common & Edwards 23.11.1976 (2) ANIC; Canberra Coast Rd, Manar Ck, Britton & Misko 18.5.1967 (2) ANIC; Canberra Coast Rd, Cabbage Tree Ck, 7.7.1965 (1) ANIC; Casino 4 mi W, E. B. Britton at light (1) ANIC; Chichester St. Forest, Allyn R. Park, J. T. Doyen 8.XI.1982 (2), T. Weir 10–11.1981 ANIC; Chiswick nr Armidale, B. Clydesdale 12.1965 (5), 2.66 (2), 6.12.67 (1) ANIC; Clarence R., Brisbane, Coates, Griffith (6) SAMA; Cooma, Duboulay (3) ANIC; Coonabarabran 9 km W, 533 m, 31°17S 149°11'E, Common & Edwards 2.12.1974 (1) ANIC Coonabarabran 9 km NNE, Newe 11 Hwy, E. Britton 24.10.1980 Pilliga scrub (2) ANIC; Coonabarabran 14 km W, nr Timor Rock, J. Doyen 4.11.1982 (3) ANIC; Culcairn, E. W. Ferguson (4) ANIC; Darling R., Bourke 20 mi.

FIGURE 22. Distribution of the studied specimens of *Paracymus pygmaeus* (MacLeay, 1871).

SSW, on bank, G. F. Gross 26.12.1973 at light (1) SAMA; Delagate 14 km W, C. Watts 4.11.1997 (2) SAMA; Deniliquin, V. R. Squires 10.2.1966 light trap (1) ANIC; Dungong 35 km N, Chichester State Forest, Telegherry Forest Park, 300 m, Pollock & Reichert 18.12.1990 UV light along river (14) NMW, MSNV; Fowlers Gap Res. Stn, 31°05'S 141°42'E, Cardale & Naumann 29.11–2.12.1981 (18) at light, ANIC; Gilgandra, C. Watts 19.11.1992 (5) SAMA; Griffith, 34°17'S 146°03'E, R. Kohout 10.5.1972 (2) ANIC; Hay 23 mi. E, Britton & Misko 23.10.1967 at light (10) ANIC; Hay 8 km W, 34°30'S 144°51'E, Britton, Misko & Pullen 14.12.1970 (10) river bank, at light, ANIC; Hay 37 km E, E. G. Matthews 10.3.1971 (5) SAMA; Jenolan Caves, vicinity, J. C. Wiburd (4) SAMA; Jindabyne 13 km NE, Kara Ck 940 m, T. A. Weir 16.3.1979 (8) ANIC, MSNV; Jindabyne 12 km NNE, The Lake Ck 1160 m, T. A. Weir 16.3.1979 (11+10 not prepared) ANIC, MSNV; Jindabyne 6 km NW, Thredbo R. 500 m, T. A. Weir 15.3.1969 (1) ANIC; Jindabyne 10 km W, Wollindibby Ck 1060 m, T. A. Weir 15.3.1969 (2) ANIC; Khancoban, below Khancoban Dam 300 m, 36°13'S 148°06'E, dry sclerophyll forest, Newton & Thayer 13.2.1987 UV blacklight along river (43) FMNH; Kiandra, Alpine Ck, E. Britton 27.1.1966 (2) ANIC; Kosciusko NP, Diggers Ck 1510 m, T. A. Weir 14.3.1969 (2) ANIC; Kosciusko NP, Betts Ck 1740 m, 36°25'S 148°22'E, alpine meadow, Newton & Thayer 14.2.1987 ex *Sphagnum* etc. at stream edge and in bog (2) FMNH; Kosciusko NP, Leather Barrel Ck 980 m, 36°32'S 148°12'E, wet sclerophyll forest, Newton & Thayer 19.12.1986 flood debris ex large log jam, large forest stream (2) FMNH; Kosciusko NP, Sawpit Ck 1200 m, T. A. Weir 14.3.1969 (7) ANIC, MSNV; Kyogle 345 m, Newton & Thayer 2.3.1980 blacklight (1) USNM; Lake Bathurst, C. Reid 17.12.1984, shore mud & on grassland (1) ANIC; Macksville, Wachtel 12.1990 (1*f*) SAMA; Merindee Lakes Pk, Trust Caravan, G.P.Gross 26.12.1973 at light (6) SAMA; Moonbi Lookout 760 m, 30°58'S 151°06'E, Common & Edwards 11.12.1974 (1) ANIC; Moruya 8 km SE, Congo 35°58'S 150°09'E, M. S. Upton 8 & 14.2.1981 (2) ANIC; Mossgiel 11 km N, Willandra Bridge

33°16'S 144°34'E, dry swamp, Britton, Misko & Pullen 21.12.1970 at light (21) ANIC; Mt Kaputar, 2000 ft, C. W. Frazier 4.9.1964, at light (2) ANIC; Mt Keira, 1000 ft, Britton & Misko 7.3.1967 at light (1) ANIC; Mudgee 4 mi SW, 32°36'S 149°35'E, Britton & Misko 18.11.1968 (1) ANIC; Namoi R., Narrabri 30°19'S 149°47'E, J. A. L. Watson 10.3.1969 at light (1) ANIC; Nelson Bay 6 mi ESE, Britton & Misko 21.11.1967 at light (6) ANIC; Queanbeyan 2.7 km NE, 670 m, I. F. B. Common 11.11.1976 (1) ANIC; Sydney 100 m, H. P. Chandler 7.3.1943 (2) FMNH; Tamworth, Lea (2) SAMA; Uralla 6 km N, CSIRO Research Stn 'Chiswick', A. G. Furnival 10.1.1972 (10), 20.11.72 (2), 30.11.73 (4) ANIC; Valery, A. P. M. *Eucalyptus* plantation, Mc Mullens Block, R. McInnes 10.1.1967 (1) light trap, ANIC; Wahroonga, H. J. Carter (4) ANIC; Warrumbungle NP, Siding Spring Mtn, C. Reid 23.XI.1985, *Eucalyptus* forest at light (8) ANIC; Wee Jasper, E. F. Riek 20.4.1961 (4) ANIC; Wentworth Fs, 5.1.1895 (1) SAMA; Wingello 3 km SW, S. Misko 20.2.1974 (4) ex pool, ANIC; Wingham Scrub, 31°52'S 152°22'E, rainforest edge, Britton & Misko 3.1.1970 (3) at light, ANIC; Woy Woy, Pearl Beach, C. Reid 1.12.1984 at light (1) ANIC. **Northern Territory**: Adelaide R., at Daly R. Road Crossing, 13°29'S 131°06'E, E. B. Britton 9.11.1972 (12) ANIC; Adelaide R., 10 km on Daly R. Road, E. F. Riek 25.10.1972 (1) ANIC; Adelaide R., 13°15'S 131°06'E, M.S.Upton 17.10.1972 (14) ANIC, MSNV; Adelaide R. 27 km N, Coomalie Ck, Gross & Forrest 28.9.1977 at light (16) SAMA; Alice Springs 6 mi SE, Emily Gap, Britton, Upton & Mc Innes 17.2.1966 (1) ANIC; Alice Springs 9 km N, Todd R., 23°38'S 133°53'E, M. S. Upton 10.10.1978 (1) ANIC; Alroy Downs HS 15 km SW, 19°24'S 135°58'E, Key & Balderson 10.4.1976 (7) ANIC; Barrow Ck 2 mi S, Britton, Upton & McInnes 13.2.1966 (4) ANIC; Boko Hill 1 km N, SW of Borroloola, 16°26'S 136°01'E, Key & Balderson 14.4.1976 (2) ANIC; Borroloola 2 km SSE, McArthur R., 16°05'S 134°19'E, J. E. Feehan 19–20.4.1976 (1) ANIC; Borroloola 4.5 km W, T. Reardon 8.1982 (1) SAMA; Borroloola 11 km SW, Goose Lagoon, 16°10'S 136°15'E, J. E. Feehan 17.4.1976 at light (9), M. S. Upton 31.10.1975 (1) ANIC; Borroloola 12 km NNE, 15°58'S 136°21'E, M. S. Upton 1.11.1975 (3) ANIC; Borroloola 22 km WSW, 16°08'S 136°06'E, J. E. Feehan 16.4.1976 at light (30), M. S. Upton 2.11.1975 (11) ANIC; Borroloola 30 km NE, Batten Point, 15°54'S 136°32'E, J. E. Feehan 18.4.1976 at light (9) ANIC; Borroloola 31 km WSW, Batten Ck, 16°10'S 136°03'E, J. E. Feehan 15.4.1976 at light (7) ANIC; Borroloola 33 km SW, Caranbirini W.H., 16°16'S 136°05'E, J. E. Feehan 21.4.1976 at light (10), M. S. Upton 3.11.1975 (10) ANIC; Borroloola 45 km SW, Surprise Ck, 16°25'S 136°05'E, M.S.Upton 5.11.1975 (1) ANIC; Borroloola 46 km SSW, 16°28'S 136°09'E, J. E. Feehan 23.4.1976 (4), M. S. Upton 28.10.1975 (1) ANIC; Borroloola 48 km SW, McArthur R., 16°27'S 136°05'E, J. E. Feehan 13.4.1976 at light (4), M. S. Upton 29.10.1975 (1) ANIC; Borroloola 54 km S, Cattle Ck, 16°32'S 136°10'E, M. S. Upton 27.10.1975 (1) ANIC; Borroloola 80 km SW, McArthur R., 16°39'S 135°51'E, M. S. Upton 13.5.1973 (10) ANIC, MSNV; Burrell's Ck, Stuart H'way, D. H. Colless 25.11.1972 at light (1) ANIC; Cahills Crossing, E Alligator River, 12°26'S 132°58'E, E. B. Britton 31.10.1972, 3.12.1972 at light (5), E. G. Matthews 29.5.1973 at light (10) ANIC, SAMA; Cahills Crossing 1 km N, E Alligator R., 12°23'S 132°57'E, Upton & Feehan 7.6.1973 (7), E. Britton 31.10.1972 at light (2) ANIC; Cahills Crossing 5 km NNW, E Alligator R., 12°23'S 132°57'E, E. B. Britton 5.11.1972 (1), E. G. Matthews 28.5.1973 (10), Upton & Feehan 8.6.1973 (4), A. H. Watson 8.6.1973 (1) ANIC, SAMA; Cahills Crossing 7 km NW, E Alligator R., 12°23'S 132°56'E, E. B. Britton 4.11.1972 at light (10), E. G. Matthews 27.5.1973 (10) ANIC, SAMA; Cape Crawford 8 km ESE, Bessie Springs, 16°40'S 135°51'E, J. E. Feehan 12.4.1976 at light (13) ANIC; M. S. Upton 26.10.1975 (11), J. E. Feehan 12.4.1976 at light (3) ANIC; Cape Crawford 14 km NW, 16°34'S 135°41'E, M. S. Upton 6.11.1975 (15) ANIC; Cape Crawford 14 km S, Mc Arthur R., 16°47'S 135°45'E, M. S. Upton 25.10.1975 (9), J. E. Feehan 11.4.1976 (16) ANIC; Colyer Lagoon, October Ck, Gross & Forrest 26–27.9.1977 at light (3) SAMA; Curtin Springs HS., Thurmer & Lacis 17.8.1978 (1) SAMA; Daly R., J. C. Lesoeuf 12.7.1971 (5) ANIC; Daly River 10 mi E, B. K. Head 28.6.1972 at light (41) SAMA; Daly R. Mission, J. Hutchinson 6.6.1974, 8.10.1974 at light (2) ANIC; Darwin, F. J. Gay 24.4.1966 (2) ANIC; Darwin, B. Malkin 25.3.1945 (1) FMNH; nr Darwin, Coastal Plains Rsrch Station CSIRO, E. C. B. Langfield 6.6.1966 at light (17), 30.5.1966 at light (8) ANIC, MSNV; Darwin 24 km S, Howard Springs, 12°28'S 131°03'E, E. B. Britton 10.11.1972 rainforest, at light (3), J. A. L. Watson 27.1.1968 at light (1) ANIC; Darwin 30 km SSE, Berry Springs, 12°41'S 130°58'E, E. B. Britton 11.11.1972 at light (2) ANIC; Darwin 50 km S,

Coomalie Ck, G. F. Gross 28.9.1977 (1) SAMA; Darwin 52 km S, Livingstone Field, Stuart Highway, 12°44'S 132°05'E, E. B. Britton 9.11.1972 at light (16) ANIC; East Point, nr Darwin, 12°28'S 130°50'E, E. B. Britton 12.11.1972 in flowers of *Hybiscus tiliaceus* (1) ANIC; Elliott 15 km SW, L. Woods, Gross & Forrest 5.10.1977 at light (25) SAMA; Groote Eylandt, N. B. Tindale, in moss and lichens (1) SAMA; Jabiru, C. Watts 22.3.1998 (6) SAMA, MSNV; Kakadu NP, Upper S Alligator R., 13°35'S 132°36'E, P. S. Cranston 4–5.6.1988 light trap (8) ANIC; Katherine, L. P. Kelsey 16.8.1973 at light (1), E. G. Matthews 6–10.2.1968 (1) ANIC; Katherine Gorge, M. J. Muller 26.10.1975 light trap (2) ANIC; Katherine 3 km SSW, 14°30'S 132°15'E, T. Weir 12.11.1979 (4) ANIC; Katherine 25 km NE, Katherine R., Gross & Forrest 3–4.10.1977 at light (24) SAMA; Koongarra 12°52'S 132°50'E, M. S. Upton 6–10.3.1973 (4) ANIC; Mataranka 5 km E, Roper R., Gross & Forrest 27.9.1977 at light (8) SAMA; Mataranka 19 km SSE, Elsey Ck, 15°05'S 133°07'E, M. S. Upton 14.5.1973 (9) ANIC; Mt Borradaile 19 km E, Cooper Ck 12°06'S 133°04'E, E. B. Britton 2.11.1972 (4), E. G. Matthews 31.5.1973 at light (25), M .S. Upton 9.11.1972 (1), 5.6.1973 (8) ANIC, SAMA; Mt Cahill 6 km E, 12°52'S 132°46'E, Nourlangie Ck, M. S. Upton 18.11.1972 (2) ANIC; Mt Cahill 8 km N, Nourlangie Ck, 12°48'S 132°42'E, E. B. Britton 26.10.1972 (14), id., D. H. Colless (1), M. S. Upton 19.11.1972 (3), Upton & Feehan 16.6.73 (23), E. G. Matthews 21.5.73 (6) at light ANIC, SAMA, MSNV; Mt Cahill 8 km E, Nourlangie Ck, 12°52'S 132°47'E, E. B. Britton 27.10.1972 (58), id., mud at edge of waterhole (7), E. G. Matthews 22.5.1973 at light (9) ANIC, SAMA, MSNV; Mt Cahill 10 km E, 12°51'S 132°47'E, E. G. Matthews 21.5.1973 (2) ANIC; Mt Cahill 12 km NNW, 12°46'S 132°39'E, E. B. Britton 25.10.1972 at light (1), Matthews & Upton 20.5.1973 (20), Upton & Feehan 15.6.1973 (3) ANIC, SAMA; Mt Cahill 15 km E, Koongarra, 12°52'S 132°50'E, M. S. Upton 15.11.1972 (11), Upton & Feehan 12.6.1973 (9) ANIC; Mt Cahill 15 km E by N, 12°50'N 132°51'E, E. B. Britton 29.10.1972 at light (4), D. Colless 30.10.1972 by sweeping (8) ANIC; Mt Cahill 16 km E by N, 12°50'S 132°51'E, Upton & Feehan 13.6.1973 (14) ANIC, SAMA; Mt Cahill 19 km NE, Baroalba Ck Springs, 12°47'S 132°51'E, E. B. Britton 28.10.1972 (43), M. S. Upton 16.11.1972 (8) ANIC; Mt Cahill 19 km WSW, Jim Jim Ck, 12°57'S 132°33'E, E. B. Britton 24.10.1972 at light (8), Upton & Feehan 17.6.1973 (6) ANIC, SAMA; Mt Cahill 30 km WSW, 12°58'S 132°26'E, E. G. Matthews 19.5.1973 (1) ANIC; Mt Cahill 46 km WSW, S Alligator River, 13°03'S 132°19'E, Matthews & Upton 20.5.1973 (7) SAMA, ANIC; Mudginbarry HS. 2 km N, Magela Ck, 12°35'S 132°52'E, M. S. Upton 14.11.1972 (9) ANIC; Mudginbarry HS. 9 km SSE, Magela Ck, 12°40'S 132°54'E, E. B. Britton 6.11.1972 at light (20) ANIC; Mudginbarry HS. 9 km N, 12°31'S 132°54'E, Upton & Feehan, E. G. Matthews 26.5.1973 (12) ANIC, Upton & Feehan 10.6.1973 (9) ANIC, SAMA, E. B. Britton 30.10.1972 (16) ANIC; Nabarlek Dam, 15 km S of Nimbuwah Rock, 12°20'S 133°19'E, E. G. Matthews 2.6.1973 at light (10) ANIC, SAMA; Nimbuwah Rock 11 km S, Cooper Ck, 12°17'S 133°20'E, E. B. Britton 1.12.1972 at light (12), Feehan & Upton 3.6.1973 (3) ANIC; Oenpelli 6 km SW, 12°22'S 133°01'E, E. G. Matthews 30.5.1973 at light (2), Upton & Feehan 6.6.1973 (5) ANIC, SAMA; Oenpelli 18 km E, 12°17'S 133°13'E, Matthews & Upton 1.6.1973 (6) ANIC; Pine Ck, C. Watts 5.5.1963 (2) SAMA; Port Keats, 14°06'S 129°33'E, M. Mendum 19.8.1968 (1) ANIC; Renner Springs 4.8 km S, N. McFarland 8.3.1966 UV light (11) SAMA; Timber Ck 4 mi W, N. McFarland 14.4.1966 UV light (67) SAMA; Tindal, 14°31'S 132°22'E, W. J. M. Vestjens 1–20.12.1967 light trap (50) ANIC, MSNV; Victoria River Downs 6.4 km SSW, L. P. Kelsey 14–17.7.1973 (4) ANIC; Victoria River Downs 4 mi. WSW, Irrigation Farm, L. P. Kelsey 13.9.1973 (2) ANIC; Victoria River Downs 8 km WSW, L. P. Kelsey 14.8.1973 at light (10) ANIC; Yuendumu, C. Watts 3.1965 (3) SAMA; Wildman River Lagoon, 12°58'S 132°00'E, E. B. Britton 24.10.1972 (6) ANIC; Woolwonga Fauna Res., Dreaming Water, E. F. Riek 20.10.1972 (2) ANIC, MSNV. **Queensland**: Annan Falls 1 km W, 15°31'S 145°14'E, E. B. Britton 26.5.1976 (7) ANIC; Archers Ck, Mt Garnet Rd., J. G. Brooks 28.12.1964 (2) ANIC; Archers Ck 2220', J. G. Brooks 18.4.1974 at light (9) SAMA; Barkley Hwy 7 mi N, on Burketown Rd., J. A. Forrest 23.9.1977 burnt out area, some regrowth, at light (1) SAMA; Boulia 42 km NNW, 22°35'S 139°43'E, M. S. Upton 11.5.1973 (1) ANIC; Bowen, A. Simson (1) SAMA; Brisbane (4) SAMA; Brisbane 50 km S, Canungra, Pollock & Reichert 11.1.1991, black light (105) NMW, MSNV; Cape York Pen., Old Strathgordon, H'stead W of Musgrave, Walford & Huggins 24.11.1983 (9) ANIC; Cardstone, J. G. Brooks 14.11.1966 (3), K. Hyde 17–23.2.1966 (13)

ANIC; Cardwell Range, J. G. Brooks 30.9.1967 (8) ANIC; Charleville S, M. S. Upton 9.5.1973 (1) ANIC; Cairns Distr., A. M. Lea, at light (6) SAMA; Chillagoe Ck, campsite, Ellis & Hawkins 8.8.1967 (1) ANIC; Cooktown, Airport Rd., roadside swamp, 15°28'S 145°11'E, E. B. Britton 24.5.1976 (9) ANIC; Cooktown 3 km S, Keatings Gap, 15°30'S 145°15'E, Common & Edwards 16.5.1977 (6) ANIC; Cooktown 21 km W, 15°25'S 145°03'E, Common & Edwards 17.5.1977 (5) ANIC; Cooktown 25 mi N, Mc Ivor R., S. R. Curtis 6.5.1970 (37) ANIC; Cooktown 75 km, Cooktown Rd., Boggy Ck, E. B. Britton 26.4.1976 (8) ANIC; Cunnamulla, A. Hardcastle (2) SAMA; Dalby, F. H. Hobler, Griffith Coll. (1) SAMA; Dalrymple 300 m, 30 km N Charters Towers (2) NMW; Eidsvold N, Burnett R., 24°46'S 152°25'E, Holloway & Misko 10.1.1970 at light (2) ANIC; Forty Mile Scrub N. P., Mt Garnet 52 km SW, 18°05'S 144°52'E, Weir & Calder 21.7.1986 (24), 55 km S, 18°06'S 144°50'E, J. Balderson 29–30.11.1981 (1) ANIC; Funnel Ck, 21°47'S 148°55'E, Britton & Misko 12.12.1968 at light (7) ANIC; Gladstone 23 km SE, Calliope R., 23°50'S 151°13'E, S. Misko 23.1.1970 (11) ANIC; Green Hills, J. G. Brooks 19.12.1967 (3) ANIC; Herberton 7 mi SW, 17°27'S 145°27'E, Britton & Misko 6.12.1968 at light (8) ANIC; Hope Vale Mission 7 km N, 15°14'S 145°07'E, T. Weir 4.10.1980 (1) ANIC; Ingham, K. L. Harley 24.2.1960 (2), 30.3.1960 (2) ANIC; Ingham 23 mi SSE, 18°58'S 146°16'E, Britton & Misko 9.12.1968 at light (69) ANIC; Iron Range, 12°42'S 143°18'E, J. G. & J. A. G. Brooks 15.5.1971 at light (1) ANIC; Julatten, Bushy Ck, 16°37'S 145°21'E, E. B. Britton 3.12.1968 from gravel at water's edge (12) ANIC; Kelly, St George R., Cooktown Rd, 16°29'S 144°47'E, E. B. Britton 22.5.1976 (1) ANIC; Kennedy Forest Rd, rainforest 18°13'S 145°47'E, Britton & Misko 8.12.1968 (1) ANIC; Kingaroy 24 mi SW, 26°44'S 151°31'E, Britton & Misko 21.11.1968 (1) ANIC; Kuranda, Barron Falls, J. G. Brooks 12.12.1964 (2) ANIC; Lake Barrine, 18–22.9.1965, E. Britton (2) ANIC; Laura, C. Watts 18.7.1982 (3), 2.8.1974 (1) SAMA; Laura 73 km NW, Hann R., 15°12'S 143°52'E, Weir & Calder 27.6.1986 (25) ANIC; Longreach 31 km NW, Darr R., 23°13'S 144°04'E, M. S. Upton 10.5.1973 (8), 22.10.1975 Darr R. (3) ANIC; L'tle Mulgrave R., J. G. Brooks 16.12.1967 (11) ANIC; MacDonald N.P., Mt Tamborine, J. & E. Doyen 26.11.1982 (1) ANIC; Mackay W, Finch Hatton Ck, 21°08'S 148°38'E, S. Misko 29.11.1968 (5) ANIC; Mackay 50 mi W, Broken River, Misko & Britton 29.11.1968 rainforest, at light (2), S. Misko 30.11.1968 (6) ANIC; Mareeba, K. & E. Carnaby 22.5.1976 (1) ANIC; Mareeba 24 km N, 16°47'S 145°22'E, J. Balderson 24–25.11.1981 (1) ANIC; Mary Ck, 16°33'S 145°12'E, Britton & Misko 4.12.1968 at light (108) ANIC; Mary Ck, 22 km N of Mt Molloy, J. G. Brooks 14.3.1970 at light (20) ANIC; Miriam Vale 21 mi S, 24°38'S 151°34'E, Britton & Misko 14.12.1968 (14) ANIC; Monto 22 km NW, Coominglah St. For., J. T. Doyen 23.12.1982 (4) ANIC; Mornington Island Mission, Aitken & Tindale 7–11.5.1963 at light (4) SAMA; Mourangee nr Edungalba, 50 mi SW of Rockampton, E. Adams 24.11.1968 at light (3), Britton & Misko 26.11.1968 at light (2) ANIC; Mt Baird 3.5 km SW, 15°10'S 145°07'E, A. Calder 3–5.5.1981 (7) ANIC; Mt Baldy nr Atherton, Forest Res. No. 194, 4000', rainforest, Britton & Misko 5.12.1968 (13) ANIC; Mt Carbine 35 km NNW, J. T. Doyen 13.12.1982 (2) ANIC; Mt Cook N. P., 15°29'S 145°16'E, A. Calder 10–12.5.1981 (1) ANIC; Mt Coolum, 26°35'S 153°05'E, Britton & Misko 15.12.1968 at light (25) ANIC; Mt Inkerman 2 mi SW, 19°45'S 147°30'E, Britton & Misko 11.12.1968 mud, lily ponds (4) ANIC; Mt Lewis, ca. 3000', rainforest, Britton & Misko at light tin working site, 3.12.1968 (2) ANIC; Mt Molloy 17.7 km N, Station Ck 427 m, J. G. Brooks 21.12.1970 (1) ANIC; Mt Tozer 3 km ENE, 12°44'S 143°14'E, Weir & Calder 28.6–4.7.1986 (23), J. C. Cardale (1) ANIC; Mt Tozer 11 km ENE, 12°43'S 143°18'E, Weir & Calder 11–16.7.1986 (5) ANIC; Mt Webb 3 km NE, 15°03'S 145°09'E, A. Calder 30.4–3.5.1981 (3) ANIC; Nettle Ck, J. G. Brooks 20.8.1969 (2) ANIC; Normanton, Tindale & Aitken 4.5.1963 at light (3) SAMA; Paluma 2 km W, Ewan Rd 800 m, 19°06'S 146°34'E, J. G. Brooks 22.2.1972 at light (1) ANIC; Paluma 9 km W, J. G. Brooks 4–13.12.1973 at light (1) ANIC; Pentland, J. C. Lesoeuf 18.7.1975 (1) ANIC; Pistol Gap, Byfield, 22°50'S 150°40'E, Britton, Holloway & Misko 10.1.1970, dry sclerophyll, at light (4) ANIC; Proserpine 8 mi NE, Brandy Ck, 20°20'5S 148°41'E, Britton & Misko 11.12.1968 at light (2) ANIC; Ravenshoe 17.7 km W, Archers Ck, J. G. Brooks 13.4.1974 (18) ANIC; Reedy St George R., Cooktown Rd, E. B. Britton 22.5.1976 (1) ANIC; Stanthorpe 9 mi. S, Conardoo, Fletcher 28°46'S 151°51'E, Britton & Misko 20.11.1968 (6) ANIC; Station Ck, J. G. Brooks 14.4.1970 (2) ANIC; Stuart R., Hale & Tindale 1–2.1927 (2) SAMA; Summit 4 km W, Cunninghams Gap N.P., J. Doyen 27–28.11.1982 (1) ANIC; Townsville, B. Malkin 1–2.1945 (2) FMNH; Townsville, P.

Ferrar 23–30.5.1968 light trap (1) ANIC; Townsville 10 m, G. Wewalka 17.1.1993 (2) NMW; Townsville 5 km N, at Town Common, 19°15'S 146°48'E, S. Misko 19.1.1970 at light (1) ANIC; Wenlock R., Xing Portland Roads Road, 13°06'S 142°56'E, Weir & Calder 17.7.1986 (1) ANIC; Woodstock 7 km S, Lansdown Station, 19°40'S 146°51'E, R. A. Barrett 16.1.1974 (4) ANIC. **South Australia**: Barossa, B. J. Burton (2) SAMA; Devon Downs, S. A. Museum Exped. (1) SAMA; Donovans 6.4 km NW, Ponds Cave, Aitken & Tindale 28.1.1965 (13) SAMA; Eyre Pen., McKeckives Spr., White Flat Rd, Bishop & Diener 14.12.1976 (8) SAMA; Eyre Pen., Strm nr Epsom Sp., White Flat Rd., Bishop & Diener 14.12.1976 (6) SAMA; Eyre Pen., Todd R., White Flat Rd., Bishop & Diener 14.12.1976 (9) SAMA; Eyre Pen., Woolshed Ck, Bishop & Diener 13.12.1976 (2) SAMA; Fairview Cons. Pk, J. A. Forrest 1.4.1982 at light (12) SAMA; Fairview Wildlife Res., 36°49'S 140°24'E, Matthews & Forrest 23.3.1981 at light (2) SAMA; Finness R., R. Malcolm 4.1976 (2) SAMA; Flinders Ranges, Arkaba Ck, E. G. Matthews 5.3.1973 (1) SAMA; Lake Fox edge, P. J. M. Greenslade 18.11.1978, ex litter samples (1) SAMA; Lake George, 37°20'S 140°10'E, Roffey & Mitchell 13.10.1972 (1) ANIC; Monarto Sth, P. McQuillan 19.1.1973 UV light (2) SAMA; Mosquito Ck SE mouth at Haks Lagoon, Thurmer & Gackle 23.4.1979 in water (1) SAMA; Mt Crawford Forrest, C. Watts 10.11.1996 (3) SAMA; Mt Gambier 27 km NE, nr Linwood Pk., swamp in Pine forest, J. A. Forrest 26.3.1982 (4) SAMA; Mt Gambier, Valley Lake, K. F. Walker 1.1.1975 (11) SAMA; Mt Remarkable NP, Mambray Ck, J. A. Forrest 7.5.1981, E. G. Matthews 17.1.1982 (7) SAMA; Murbko, R. Murray, G. F. Gross 20.2.1973 (2) SAMA; Murray R., R. J. Burton (3) SAMA; Mylor, Scout Jamboree 20.12.1973–6.1.74, el. light (1) SAMA; Nanam's Well 15 km SW, Scorpion Springs C.P., Museum Party 14.12.1983, at light (2) SAMA; New Kalamurina St., Warburton R., Matthews & Houston 9.3.1972 (1) SAMA; Olary 24 km WNW, 32°17'S 140°19'E, Britton, Misko & Pullen 20.12.1970 at light (3) ANIC; Oodnadatta, Blackburn (1) SAMA; Penola Cons. Pk, Penola 14 km W, J. A. Forrest 24.3.1982 (1) SAMA; Penola W nr Calectasia NP, Baker Range Drain, J. A. Forrest 24.3.1982 (12) SAMA, MSNV; Port Lincoln, Blackburn (5) SAMA; Robe 10 km S, C. Watts 1.1983 (2) SAMA; Rudall 2 km S, 33°41'S 136°16'E, Britton, Misko & Pullen 18–19.12.1970 (1) ANIC; Salt Creek 17 mi SE, Gross & Aitken 14.1.1962 at light (3) SAMA; Tintinara 15 mi E, Jimmy's Well, Aitken & Tindale 3.2.1965 (2) SAMA; Yorke Pen., 8 km WSW Carritin Hs., S end of Formby Lisy, N. McFarland 4.11.1965 (1) SAMA. **Tasmania**: Barrow Ck, Mt Barrow 6 km NW, 41°21S 147°22'E, E. & S. Britton 3.2.1973 (1) ANIC; Forest Reefs, Griffith Coll. (4) SAMA; Frankford, A. M. Lea (2) SAMA; George, C. E. Cole 3.11.1917 (2) SAMA; Hobart, base Mt Wellington, L. Hill 26.1.1979 ex moss & grass (1) ANIC; Kelso (1) SAMA; Kempton Water Tray, L. Hill 28.11.1985 (1) ANIC; Launceston, F. M. Littler (2) SAMA; Orford 4 km W, 42°34'S 147°50'E, J. C. Cardale 27.1.1983 at light (1) ANIC; Tooms R., 460 m, 42°13'S 147°46'E, L. Hill 19.4.1981 (4 *ff*) ANIC, MSNV. **Victoria**: Alexandra 25 km S, Cathedral Range Nat. Park, Blackwood flat Campground, 445 m, Pollock & Reichert 5.12.1990 black light (1*f*) NMW; Ballarat, W. W. Froggatt (1) ANIC; Baw Baw Alpine Res., Neulines Mill 1.2 km NW, 1145 m, 37°51'S 146°15'E, wet sclerophyll & *Nothofagus cunninghami*, Newton & Thayer 29.1.1987 berlese leaf and log litter forest floor (1*f*) FMC; Billabong, Yara Glen, A. Fletcher 20.4.1976 (1) SAMA; Birchip V., J. C. Goudie (1*f*) ANIC; Dartmooor 5 km NE, C. Watts 11.10.1997 (1) SAMA; Dimboola, Caravan Park, S. Misko 18.11.1973 light trap (5) ANIC; East Pomborneit, 24 km ESE Campdown, temporary pond, P. S. Lake 5.X.1978 (5) ANIC; Healesville, Goudie & Lea 11.? (1), C. Watts 12.1968 (5) SAMA, MSNV; Kawarren 3 km N, Otway Ranges, Gross & Aitken 15.1.1962 at light (14) SAMA; Kerang, R. Blackwood 4.1935 (1) ANIC; Lake Hattah (4) ANIC; Lake Hattah, G. W. Anderson 24–25.10.1967 (2), 28.11.1967 (4), 9–15.3.1969 (2), 9.12.1969 (4) light trap ANIC; Lake Learmonth, E. F. Riek 15.12.1966 (2*ff*) ANIC; Lerderderg R., 3.8 km WNW Blackwood, A. J. Boulton 27.6 & 25.11.1982 (3) ANIC; Lilydale, A. Fletcher 2.7.1976 (1) SAMA; Lorne, Cressy Ck, N. B. Tindale 21.1.1963 (5) SAMA; Mirrantwa 10 km NE, C. Watts 12.10.1997 (11) SAMA; Mt Buffalo, Blackburn (5) ANIC, SAMA; Mt Buffalo NP, 1310 m, alpine bog, *Sphagnum* moss, Newton & Thayer 18–19.1.1980 (1) FMNH; Noojee 6 km N, C. Watts 8.11.1997 (2) SAMA; Orbost 12 km SW, C. Watts 5.11.1997 (5) SAMA; Otway NP, Binn Rd. 450 m, Cape Horn 58 km N, 38°42'S 143°34'E, wet sclerophyll forest, Newton & Thayer 24.1.1987 (1) FMNH; Ovens R., Wangaratta, Newton & Thayer 9.1.1980 black light (1*f*) ANIC; Ovens R., Porepunkah, 300 m, 36°42'S 146°55'E, mixed dry sclerophyll and

exotic trees, Newton & Thayer 12.2.1987 UV blacklight nr River (1*f*) FMNH; nr Porepunkah, A. Newton 18.1.1980 UV light (1) ANIC; Portland 30 km W, C. Watts 10.10.1997 (2) SAMA; Shepperton 13 km SE, S. Misko 22.11.1973 (2*ff*) ANIC; Tangil River E, C. Watts 8.11.1997 (8) SAMA; Violet Town 14 km NW, Rd to Shepperton, S. Misko 22.XI.1973 (5) ANIC; Yarra River, Healesville 4,5 km SW, 80 m, 37°41'S 145°29'E, dry sclerophyll forest, Newton & Thayer 6.2.1987 UV black light along river (195) FMNH; Warburton, A. Newton 13–17.1.1980 UV light (1*f*) ANIC; Warburton 12 km E, 215 m, *Eucalyptus* forest, leaf litter stream edge, Newton & Thayer 12–16.1.1980 (1) FMNH; Wyperfield Nat. Park, Frew's Plain 35°37'S 142°01'E, S. Misko 15–17.XI.1973 at light (14) ANIC, MSNV; Wyperfield Nat. Park, Lowan Treck 35°35'S 142°05'E, S. Misko 16.XI.1973 light trap (21) ANIC, MSNV; Wyperfield Nat. Park, Ranger's House, 35°37'S 142°01'E, Misko & Anderson 17.XI.1973 light trap (4) ANIC; Wyperfield NP, Common-Upton 5.11.1966 (1) ANIC. **Western Australia**: Albany, K. & E. Carnaby 15.12.1976 (5) ANIC; Albany 48 km N, Porongorup NP, J. Kethley 24.12.1976 soil litter und grasses (1) FMNH; Appleton, F. H. Uther Baker, 4.1.1966 (10) ANIC; Armadale 15 mi SSE, Pipehead Dam, M. S. Upton 26.1.1967 (7) ANIC; Armadale, D.E. 7.1961 (1) SAMA; Beverley, A. M. Lea 1870 (5) SAMA; Bunbury, K. & E. Carnaby 31.12.1971 at light (14) ANIC; Bunbury, Whitlock (7) ANIC; Capel, E. Britton 29.10.1965 (6) ANIC; Carson Escarpment, 14°49'S 126°49'E, Common & Upton 9–15.8.1975 (11) ANIC, MSNV; Collie 16 mi N, Common & Upton 7.4.1968 (1) ANIC; Coodanup nr Mandurah, T. E. Bellas 12.1979–1.1980 (1) ANIC; Darling Rgs., A. M. Lea (1) SAMA; Deepdene, Karridale, M. S. Upton 18.1.1967 (10) ANIC; Denmark, Walpole Rd, roadside pool, E. Britton 21.9.1965, 24.9.65 (2) ANIC; Denmark 14 mi E, Parry's Inlet turnoff, 35°01'S 117°09'E, E. Britton 9.11.1969 roadside pond (45) ANIC; Donnybrook, A. M. Lea 1870 (3) SAMA; Drysdale R., 15°02'S 126°55'E, Common & Upton 3–8.8.1975 (10) ANIC; Drysdale R., 14°39'S 126°57'E, Common & Upton 18–21.8.1975 (10) ANIC, MSNV; Dunsborough 20 m, J. B. Kethley 11.1976 at light (1) FMNH; Esperance 20 km E, 33°50'S 122°06'E, J. F. Lawrence 8.11.1977 at light (16) ANIC; Esperance 101 km E, Thomas R., 33°51'S 121°53'E, Britton, Taylor & Upton 20.11.1969 at light, beach dunes (24) ANIC; Fitzroy R., K. & E. Carnaby 16.4.1976 at light (7) ANIC; Fitzroy Crossing, K. & E. Carnaby 18.4.1976 at light (5) ANIC; Fremantle 10 km S, C. Watts 24.10.1996 (1) SAMA; Fremantle, North Lake, H. Demarz 30.1.1954 (2) FMNH; Geraldton 11 km N, N. McFarland 12.11.1972 UV light (3) ANIC; Hyden E, K. & E. Carnaby 5.2.1977 (1) ANIC; Julimar St. Forest, E. Matthews 9.10.1967 (2) ANIC; Kimberley E, Benn R., Helms (6) SAMA; Kimberley E, Upp. Ord R., Helms (1) Griffith Coll., SAMA; Kuliba, Ravensthorpe-Hopetoun, E. Britton 21.9.1965 (1) ANIC; Kununurra nr. Wyndham, Kimberley Research Station, 15°28'S 128°06'E, 27.XI.1956 (31) ANIC, MSNV; Kununurra, E. G. Matthews 13–22.2.1968 (1) ANIC; Kununurra 100 mi E, J. A. Mahon 27.3.1966, light trap (1) ANIC; Margaret R., roadside pond, E. Britton 29.9.1965 (1) ANIC; Mitchell Plateau, 14°40'S 125°44'E, B. V. Timms 23.9.1982 (1) SAMA; Mitchell Plateau, King Ed. R. crossing, Rd., J. B. Kethley 14.10.1976 at light (1) FMNH; Mitchell Plateau, Mining Camp, 14°49'S 125°50'E, Naumann & Cardale 9–19.5.1983 at light (7) ANIC; id., Rentz & Balderson 9–19.5.1983 on light sheet (5) ANIC; id. 3 km NW, 14°48'S 125°49'E, Rentz & Balderson 15.5.1983, airstrip (4) ANIC; id. 4 km S, 14°52'S 125°50'E, Rentz & Balderson 13.5.1983, crusher at light (17) ANIC; id. 10 km NW, 14°45'S 125°47'E, Rentz & Balderson 11–17.5.1983 (2) ANIC; Mowen 10 mi E, Margaret River, 33°57'S 115°34'E, E. Britton 14.11.1969 roadside pond (10) ANIC; Mt Arid 23 km NW, Thomas River 33°51'S 123°00'E, J. F. Lawrence 4–7.11.1977 (14) ANIC; Mt Chudalup St. Pk, North Cliffs 16 km S, J. Kethley 4.12.1976 wet moss on sand over seepage area (1) FMNH; Nannup, Augusta Rd., E. Britton 28.9.1965 (1) ANIC; Osmington 5 mi N, nr Margaret R., 33°57'S 115°04'E, E. B. Britton 15.11.1969 edge of roadside pool (3), under bark of recently felled trees (1) ANIC; Pago Mission 3 mi SE, J. B. Kethley 26.10.1976 at light (3), 27.10.1976 small pool (6) FMNH; Perth, Floreat Park, M. S. Upton 21.1.1967 (1) ANIC; Perth E, Orange Grove Caravan Pk Gosnells, Reid & Gullan 5.1.1986 at light (2) ANIC; Perth S, Yule Brook Univers. Res., C. Reid & P. J. Gullan 7–8.1.1986 at light (23) ANIC; Perth 30 km N, C. Watts 14.10.1996 (3) SAMA; Picton Junction, swamp nr Ferguson R., Britton & Uther Baker 30.11.1965 (16) ANIC; Pinjarra, Lea 1870 (10) SAMA; Pinjarra 8 mi E, South Dandalup R., 32°35'S 115°53'E, E. Britton 17.11.1969 clear brook flowing over stones (42) ANIC, MSNV; Pinjarra 6 km S, C. Watts 6.10.1996 (9) SAMA; Walpole Rd, Nornalup.

Beach Rd, S. & J. Peck 20–26.6.1980, flight intercept traps (2) ANIC; Walsh Pt 5 km W, 14°34'S 125°48'E, Rentz & Balderson 10.5.1983 (2) ANIC; Wilga, K. & E. Carnaby 11.1973, 8.12.74 etc. (33) ANIC; William Bay, stream on road to, E. Britton 24.9.1965 (3) ANIC; Wyndham, K. & E. Carnaby 20.4.1976 at light (1) ANIC; Yanchep NP, Yanchep 9 mi N, Common & Upton 12.4.1968 (1) ANIC.

Biology

From label data I extracted the following indications about the habits of *P. pygmaeus*. Most specimens are collected in flight: at light, light trap, on light sheet, UV light, black light, flight intercept traps, window-trough traps. Another method is collecting along edges, shores or banks of brooks, creeks, rivers, pools, bogs, swamps, waterholes, ponds and lakes: in mud, sand, gravel, aquatic plants such as lilies, *Sphagnum*, moss, and lichens; more rarely in open water. Also, litter is a source of specimens: wet rotting wood, bark of fallen trees, leaves on forest floor, soil and grasses, floating debris. Exceptional captures are: from nest of buff-tailed thornbill; in flowers of *Hybiscus tiliaceus*; on *Acacia* spp.

2. *Paracymus spenceri* Blackburn, 1896

Paracymus spenceri Blackburn 1896: 256–257; d'Orchymont 1942: 59–60; Wooldridge 1976: 454–455; Hansen 1999: 114.

Paranacaena spenceri (Blackburn): Knisch 1924: 168.

Types

Lectotype male: **Northern Territory**: Paisley Bluff, Reedy Creek, Blackburn Coll. NHML. A single pin bears the following cards and labels: 1. Insect (and) I, 5480, Reedy Cr., male; 2. Aedeagus (on transparent card); 3. Type (round label with red border); 4. Australia, Blackburn Coll., B.M. 1910 – 236; 5. Paracymus spenceri Blackb.; 6. Paranacaena spenceri Blackb., LECTOTYPUS male, E. Gentili 1991, Aedeagus in DMHF soluble in distilled water. *Paralectotype*: **Northern Territory**: Paisley Bluff, Reedy Creek SAMA. A single pin bears: 1. Insect (dorsally glued, and) 5480, Reedy Creek; 2. Paracymus spenceri Blackb., co-type; 3. Paracymus spenceri Blackb., Paralectotypus, E. Gentili 1992 (red label); 4. S. A. Museum specimen (red label). The Blackburn description records four typical specimens from Paisley Bluff, Reedy Creek; I did not see other types.

Description

Length 1.5–2.3 mm; width 0.8–1.3 mm. Elongate oval, slightly convex (Figs 18, 19). Head black, sometimes with violet reflection, evenly punctured, surface shining between punctures, occipital region alutaceous; only lateral branches of Y-suture scarcely conspicuous. Pronotum dark as head, becoming yellow to mahogany at sides; punctation thicker than on head, surface shining between punctures. Elytra mahogany or red-brown, lighter near apical region; punctation as on pronotum but less evident, without serial arrangement; some specimens nevertheless have traces of serial punctures due to partial transparency of elytra; parasutural furrow in apical 2/3 of elytra or a bit less. Underside dark; prosternum with longitudinal keel; mesosternum carinate with an arrow-like keel; first visible abdominal ventrite laterally shorter than second, centrally with thin longitudinal keel. Maxillary palpi yellow, tips darker; antennae eight-segmented, yellow with darker club. Profemora ventrally pubescent on basal 3/4 (or 2/3), male protarsi with a blunt spine under last segment; mesofemora pubescent near base; metafemora without hydrofuge hairs. Aedeagus as in Figs 6–8, tegmen nearly as long as parameres, with a cardioid form; parameres progressively narrowing but slightly expanded laterally at their tip; penis roughly triangular, provided with a subapical collar.

Discussion

Easy to distinguish among Australian *Paracymus* by the contrasting colour of the pronotum/elytra. The male protarsus is thinner, and the profemoral pubescence thicker than in *pygmaeus*. The shape of the aedeagus is near to that of *pygmaeus*, but the outline of the tegmen and parameres is more curved, and the preapical collar lacks any membranous expansion.

Material examined (Fig. 23)

Australian Capital Territory: Black Mountain, I. F. B. Common 25–26.12.1964 light trap (1), 6.1.1966 light trap (1), M. S. Upton 22.12.1966 light trap (1) ANIC. **New South Wales**: Dorrigo NP, E end, Blackbutt Track 710 m, subtropical rainforest, Newton & Thayer 28.2–5.3.1980 in and under rotting fruits of *Endiandra introsa* (1) USNM; Nightcap NP, Mt Nardi, Newton Drive 700 m, warm-temperate rainforest, 28°33'S 153°17'E, Newton & Thayer 4.1.1987 Berlese leaf and log litter, forest floor (5) FMNH; Uki 18 km W, Mebbin St. For., J.

FIGURE 23. Distribution of the studied specimens of *Paracymus spenceri* Blackburn, 1896.

Doyen 23–24.11.1982 (1) ANIC. **Northern Territory**: Alice Springs 80 mi NW, C. Watts 2.1968 (5) SAMA; Alice Springs 5 mi N, Wigley Waterhole, Britton Upton & McInnes 16.2.1966 (2) ANIC; Alice Springs 6 mi SE, Emily Gap, Britton Upton & McInnes 17.2.1966 (2) ANIC; Alice Springs 9 km N, Todd R., 23°38'S 133°53'E, M. S. Upton 10.10.1978 (3) ANIC; Alice Springs 33 km WNW, 23°36'S 133°34'E, M. S. Upton 30.9.1978 (3) ANIC, MSNV; Alice Springs 99 km NE, Ongeva Ck, 23°01'S 134°29'E, M. S. Upton 13.10.1978 (1) ANIC; Batchelor 1 km SE, N. McFarland 12.4.1966 UV light (3) SAMA; Borroloola 11 km SW, Goose Lagoon, 16°10'S 136°15'E, J. E. Feehan 17.4.1976 at light (4) ANIC, MSNV; Borroloola 22 km WSW, 16°08'S 136°06'E, J. E. Feehan 16.4.1986 at light (1) ANIC; Borroloola 30 km NE, Batten Point, 15°54'S 136°32'E, J. E. Feehan 18.4.1976 (1) ANIC; Borroloola 31 km WSW, Batten Ck, 16°10'S 136°03'E, J. E. Feehan 15.4.1976 at light (1) ANIC; Borroloola 45 km SW, Surprise Ck, 16°25'S 136°05'E, J. E. Feehan 14.4.1976 at light (1) ANIC; Borroloola 48 km SW, McArthur R., 16°27'S 136°05'E, J. E. Feehan 13.4.1976 at light (1) ANIC; Edith Falls, J. C. Lesoeuf 8.7.1971 (1) ANIC; Mt Cahill 8 km N, Nourlangie Ck, 12°48'S 132°42'E, Upton & Feehan 16.6.1973 (1) ANIC; Renner Springs 4.6 km S, N. McFarland 8.3.1966 UV light (1) SAMA; Timber Ck 4 mi W, N. McFarland 14.4.1966 (2) SAMA; Wauchope 30 km N, 20°22'S 134°14'E, M. S. Upton 13.10.1972 (5) ANIC, MSNV. **Queensland**: Archer R., C. Watts 28.10.1984 (1) SAMA; Barkley Hwy 7 mi N, on Burketown Rd, J. A. Forrest 23.9.1977 burnt out area some regrowth, at light (1) SAMA; Cairns, Edge Hill, J. G. Brooks 11.11.1967 (1) ANIC; Cardstone, K. Hyde 9–13.3.1966 (3) ANIC; Cooktown Rd 75 km, Boggy Ck, E. B. Britton 26.4.1976 (3) ANIC; Eidsvold N, Burnett R., 24°46'S 152°25'E, Britton. Holloway & Misko 10.1.1970 at light (2) ANIC; Forty Mile Scrub Nat. Pk, Mt Garnet 52 km SW, 18°05'S 144°52'E, Weir & Calder 21.7.1986 (2) ANIC; Funnel Ck 21°47'S 148°55'E, Britton & Misko 12.12.1968 at light (4) ANIC, MSNV; Ingham 23 mi SSE, Crystal Ck, 18°58'S 146°16'E,

Britton & Misko 9.12.1968 at light (2); Laura, C. Watts 18.7.1982 (2) SAMA; Monto 22 km NW, Coominglah St. For., J. T. Doyen 23.12.1982 (1) ANIC; Mornington Island Mission, Aitken & Tindale 11.5.1963 at light (1) SAMA; Normanton, Tindale & Aitken 4.5.1963 at light (1) SAMA; Pentland, J. C. Lesoeuf 12.7.1975 (1) ANIC; Station Ck, J. G. Brooks 19.4.1970 (3) ANIC; Townsville, P. Ferrar 19.11.1967 light trap (1) ANIC; Tully 40 km W, E. F. Riek 31.5.1971 (3) ANIC, MSNV. **South Australia**: Chambers Gorge, C. Watts 9.1983 (5) SAMA; Enorama Ck, Amena Valley Rd, Nth. Flinders, Suter Mitchell & Marchant 26.7.1976 (1) SAMA; Flinders Ra., Arkaba Ck, E. G. Matthews 5.3.1973 (10) SAMA, MSNV; Flinders Ra., Blinman 12 km NW, I & II springs, J. A. Forrest 10.5.1981 (2) SAMA; Flinders Ra., Brachina Ck nr. Heysen Hill, J. A. Forrest 9.5.1981 (1) SAMA; Flinders Ra., Eringunda V., E. G. Matthews 6.3.1973 (2) SAMA; Flinders Ra., Parachilna Gorge, C. Watts 10.1981 (1) ANIC; Flinders Ra., Wooltana HS 6 km SW, Munyallina Ck, J. A. Forrest 12.5.1981 (1) SAMA; Manu Ra., Angatja homestead 5 km N, damp litter, L. E. Watrous 11.5.1983 (3) FMNH; Mt Remarkable, L. E. Watrous 29.4.1983 black light (1) FMNH; Musgrave Ra., Ernabella 13 km N, L. E. Watrous 7.5.1983 (12) FMNH; Musgrave Ra., Rock Hole, SSE Mt Woodruffe, L. E. Watrous 8.5.1983 black light (7) FMNH; Owieandana, N Flinders Ra., Hale & Tindale (2) SAMA; Parachilna, Flinders Ra., Griffith Coll., (1) SAMA; Quorn 30 km NNW, Buckaringa Gorge, C. Reid 18.12.1985 (2) ANIC; Woodendina Ck, Nirrana, Flinders, Bishop & Diener 16.12.1976 (4) SAMA, MSNV. **Victoria**: Turtons Track, Otway Ranges, Gross & Aitken 17.1.1962 (1) SAMA. **Western Australia**: Beverley, Griffith Coll. (7) SAMA, MSNV; Cane River HS. 17 km N, 21°56'S 115°39'E, Upton & Mitchell 27.4.1971 (5) ANIC, MSNV; Carson Escarpment, 14°49'S 126°49'E, Common & Upton 9–15.8.1975 (7) ANIC, MSNV; Dampier, Dampier Is., Intercourse, pool standing water, J. B. Kethley 2.10.1976 (2) FMNH; Derby, W. D. Dodd (1) SAMA; Kimberley Bore, K. & E. Carnaby 13.3.1980 at light (1) ANIC; Kimberley W, Cape Bertholet 8 km S, 17°19'S 122°10'E, D. H. Colless 19.4.1977 (1) ANIC; Millstream, 21°35'S 117°04E, E. B. Britton 28.10.1970 at light, open eucalypt paperbark woodland (2) ANIC; 28.10.1970 at light, open eucalypt-paperbark woodland kangaroo grazed grass (1) ANIC; 28.10.1970 Crystal Pool (4) ANIC; 29.10.1970 shallow stream (18) ANIC; 29.10.1970 at light spinifex-eucalypt junction (22) ANIC; 30.10.1970 eucalypt-spinifex (2) ANIC; 31.10.1970 (10) ANIC; 1.11.1970 gravel at margin of Crossing Pool (24) ANIC; 2.11.1970 from gravel at edge of pool at pipe crossing (82) ANIC, MSNV; 1.11.1970 at light, eucalypt-paperbark woodland (1) ANIC; 2.11.1970 palm-eucalypt-melaleuca assocn, at light (6) ANIC; 3.11.1970 shallow weed-grown pool (2) ANIC; 3.11.1970 at light (28) ANIC; 4.11.1970 Crossing Pool, at light (1) ANIC; 5.11.1970 waterside gravel in pipe, Crossing Pool (16) ANIC; 5.11.1970 eucalypt-spinifex, at light (2) ANIC; 5.11.1970 Crystal Pool, at light (14) ANIC; 7.11.1970 mouth of Dawson's Ck (17) ANIC; 8.11.1970 Deep Reach, at light (3) ANIC; Millstream, Crossing Pool, D. H. Colless 21.10.1970 (2) ANIC; Millstream HS, E. F. Riek 4.4.1971 (5) ANIC; Millstream HS. ½ km WNW, 21°35'S 117°04'E, M. S. Upton 21.10.1970 (4), Upton & Mitchell 14.4.1971 (24) ANIC, MSNV; Millstream 1 km NE, 21°35'S 117°04'E, M. S. Upton 24.10.1970 (14) ANIC; Millstream 1 km NNE, M. S. Upton 3–4.4.1971 (14) ANIC; Millstream 1 km N, M. S. Upton 9–10.4.1971 (3) ANIC; Millstream 2 km ENE, M. S. Upton 21.10.1970 (1) ANIC; Millstream HS. 3 km NW, 21°34'S 117°03'E, Upton & Mitchell 22.4.1971 (7) ANIC; Millstream HS. 5 km SE, 21°37'S 117°06'E, Upton & Mitchell 17.4.1971 (1) ANIC; Millstream 8 mi ENE, D. H. Colless 20.10.1970 (5) ANIC; Millstream 15 km E, 21°35'S 117°12'E, M. S. Upton 20.10.1970 (8) ANIC; Minilya R., 23°49'S 114°00'E, Upton & Mitchell 29.3.1971 (14) ANIC, MSNV; Mitchell Plateau, Mining Camp, 14°49'S 125°50'E, Rentz & Balderson 9–19.5.1983 (1) ANIC; id., 4 km S, 14°52'S 125°50'E, Rentz & Balderson 13.5.1983 (1) ANIC; Mt Magnet, K. & E. Carnaby 28–29.9.1978 (1) ANIC; Newman 13 km E, 23°15'S 119°52'E, E. B. Britton 12.11.1970 (8) ANIC; Walsh Pt 8 km SW, Escarpment, 14°37'S 125°48'E, Rentz & Balderson 10–17.5.1983 (1) ANIC; Wittenoom 13 km ESE, 22°18'S 118°27'E, E. B. Britton 11.11.1970 (1) ANIC.

Biology

The label data are scarcer than for *pygmaeus*, but similar. The species is collected most frequently at light (also UV light, black light), then at edge of standing or flowing water, e.g. in gravel, and occasionally in damp leaf and log litter on the forest floor. An exceptional capture is in and under rotting fruits of *Endiandra introsa*.

3. *Paracymus gigas* Gentili, 1996

Paracymus gigas Gentili 1996: 178; Hansen 1999: 111.

Types (Fig. 24)

Holotype male: **Western Australia**: Mitchell Plateau, Amax Warrender Rd 3 mi W, J. B. Kethley 21.10.1976, spring pool drainage, FMNH.

Description

Length 3.0 mm, width 1.8 mm. Convex, widely oval, black. Head 1.5 x as wide as long, black, densely punctured, interspaces once to twice width of punctures; anterior margin of labrum uniformly curved; eye/interocular space ratio nearly 0.7. Pronotum black with testaceous lateral margins, sides strongly curved; densely punctured as head, between punctures slightly shagreened. Scutellum black, trapezoidal, elongate, slightly protruding anteriorly. Elytra black, pale near lateral borders, with normally developed parasutural furrows, punctures somewhat denser than on pronotum and head, shagreened between punctures. Postlabium rectangular, flat and smooth; antennae 9-jointed; maxillary palpi long 0.6 x width of head; eyes large below. Prosternum with longitudinal keel; mesosternum with arrow-head-like keel; metasternum raised in middle, with conspicuous triangular dimple in raised area; abdominal ventrites pubescent. Profemora ventrally pubescent, mesofemora so only on and near trochanters, metafemora glabrous. Aedeagus as in Figs 11, 12: tegmen pointed at base, longer than parameres, ventrally protruding and covering base of penis with a jut; parameres blunt at apex and interiorly scythed; penis progressively constricted from base to apex, this slightly expanded as a button.

Discussion

Larger than all described Australian *Paracymus*, this species is immediately identified by its long maxillary palps, the 9-segmented antennae, and the metasternal dimple. The length of the palps and the shape of the aedeagus (e.g. tegmen with a

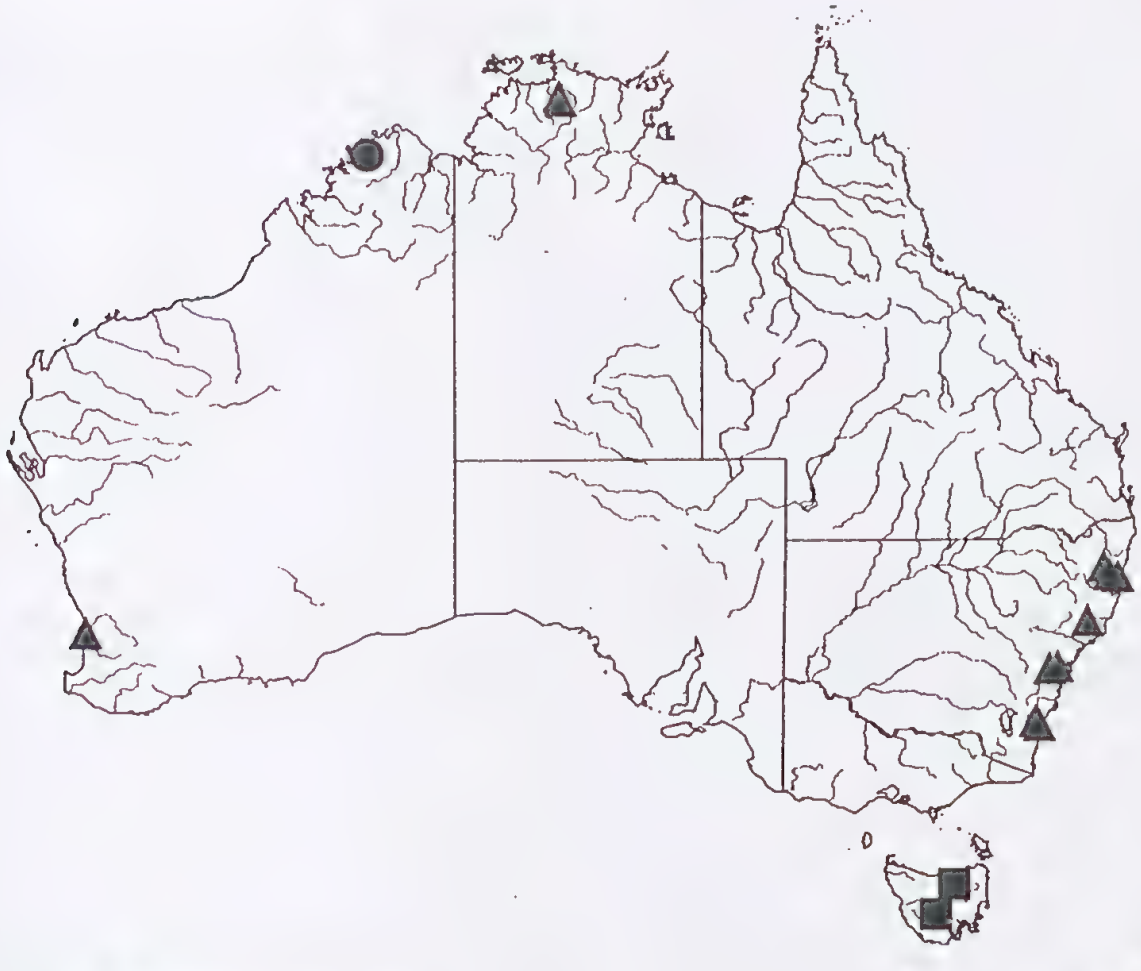


FIGURE 24. Distribution of the studied specimens of *Paracymus wattsi* n. sp. (▲), *cariceti* n. sp. (■), *gigas* Gentili, 1996 (●).

ventral jut covering the base of the penis) might suggest that it belongs to the genus *Notohydrus*; but the longitudinally keeled prosternum suggests the genus *Paracymus*.

4. *Paracymus cariceti* n. sp.

Types (Fig. 24)

Holotype male (1.7 x 1.1 mm): **Tasmania**: 42°32'S 146°30'E, Map 8212.593.923, Adj. Misery Creek 780 m, 21.2.1980, L. Hill coll., short sedge and rush turfs, ANIC, CSIRO. *Paratype*: **Tasmania**: male (without aedeagus, previously lost): Tasmania, Launceston, SAMA. Another specimen in SAMA, a female, labelled 'Launceston, Tas., Jan., C. Watts', might belong to this species, but apart from the slightly greater size it has the first abdominal segment with a longitudinal keel, lacking in the two typical males.

Description

Length 1.7–1.8 mm; width 1.0–1.1 mm. Widely oval, slightly convex. Dorsally black, head with metallic reflections, pronotal borders and elytral apex darkly testaceous. Labrum centrally hollow; anterior margin of clypeus straight; head, under 100 x magnification, slightly shagreened, with scarcely visible punctures; interocular space 3.6 x eye width. Pronotum smooth, with sparse punctures clearly visible at 100 x magnification, space between them nearly as large as punctures. Scutellum triangular, equilateral, smooth, with scarce and fine punctures. Elytra smooth, with a more or less faint shagreen at 100 x, with sparse punctures as on pronotum; parasutural furrow in apical 2/3 or a bit less. Underside testaceous, head black. Postlabium nearly rectangular, flat, smooth and shining; gula smooth. Prosternum carinate with a high longitudinal keel; mesosternum anteriorly provided with transverse tooth, and posteriorly with longitudinal keel; metasternum concealed under recumbent hairs. Five visible abdominal ventrites, glabrous and smooth, the first being the shorter, the last the longer; first ventrite without a longitudinal keel but with scarcely visible tubercle along central line; if specimen from Launceston previously recorded belongs to this species, female has a keel on first ventrite. Palps short and stout; profemora pubescent along anterior margin; mesofemora pubescent to knees; metafemora with scarce hairs near trochanters. Aedeagal length (Fig. 9) between 1/3 and 1/4 of body; tegmen narrow at its base, much shorter than parameres; these acute and longer than penis; penis basally swelling, then rod-like, anchor-shaped at tip, without any collar.

Discussion

This Tasmanian species differs from other Australian *Paracymus* chiefly by its aedeagus, which has the tip of the penis anchor-shaped at the apex, and the apex of the parameres acute. Other unique characters are the mesofemur which is completely pubescent on its ventral face, and the first ventrite having a tubercle instead of a longitudinal keel. Size and colour are similar to small *P. pygmaeus*; but it differs from this species in the aedeagus, which has a shorter tegmen, and the features mentioned; in its shorter and wider body shape; in its shorter and stouter palps; and in having the first abdominal segment not keeled.

Biology

The name *cariceti* comes from a label note: short sedge and rush turfs.

5. *Paracymus ovum* n. sp.

Types (Fig. 25)

Holotype male (2.8 x 1.45 mm): Kalbarri Nat. Pk, Northampton 54 mi N, Common & Upton 19.4.1968, ANIC; *paratypes* (3): same data as the holotype, ANIC, SAMA, MSNV.

Description

Length 2.5–2.8 mm; width 1.35–1.45 mm; elongate oval, slightly convex (Figs 18, 19). Head black, irregularly punctured, interspaces alutaceous or smooth, as large or larger than punctures, these less strong and deep than in *weiri*; labrum nearly concealed under head; eyes together as wide as nearly 4/7 of interocular space; Y-suture conspicuous only as periocular groove. Pronotum black with thin testaceous lateral border; punctures irregularly distributed as on head, a little more faint, interspaces alutaceous (chiefly on borders) or smooth (chiefly on disc); anterior corners clearly produced. Scutellum triangular, longer than wide. Elytra black with thin testaceous border; punctured as on pronotum, partly alutaceous; parasutural furrow in apical 2/3 or a bit less. Underside dark; postlabium smooth with small punctures; prosternum roof-like, keeled; mesosternal keel anteriorly like an arrow-head; metasternum posteriorly with glabrous area surrounded by tufts of hairs; first abdominal ventrite centrally covered with flat longitudinal keel, enlarging anteriorly. Palps yellow, second

joint enlarged, last joint more slender than in *weiri*; antennae 8-segmented, yellow with a dark club. Profemora widely hairy, mesofemora only on basal third, metafemora glabrous. Aedeagus (Fig. 17) concave at base, tegmen nearly as long as parameres, these blunt at apex; penis rod-like with small subapical expansion or collar.

Discussion

Only the shape of the aedeagus differentiates *ovum* from all other Australian *Paracymus*; other differences are combinations of characters. It is similar to *weiri*, but differs in having a more slender, nearly parallel-sided body (Figs 18, 19); an upperside partly alutaceous; a flat keel on the entire first ventrite; a different aedeagus: tegmen shorter (in *weiri* it is longer than parameres, in *ovum* subequal), and penis less stout.

6. *Paracymus wattsi* n. sp.

Paracymus phalacroides Wooldridge 1978: 129; Hansen 1999: 112.

Types (Fig. 24)

Holotype male (1.7 x 1.0 mm): **New South Wales**: Barrington, NSW, 17.8.1997 C. Watts, SAMA; aedeagus preserved in DMHF. *Paratypes:* **New South Wales**, same data (2 females) SAMA; Batemans Bay 2 km N, C. Watts 18.4.1997 (5 males 3 females) SAMA, MSNV; Blue Mountains, Faulcon Bridge 500 m, G. Wewalka 15.1.1993 (1male 2 females) NMW, MSNV; Cabbage Tree Creek, Nelligan 20 km W, C. Watts 30.11.1995 (1male) SAMA; Dorrigo, W. Heron (1 female) ANIC [*Paracymus phalacroides*? det. D. P. Wooldridge]; Failford 8 km N, C. Watts 18.8.1997 (2 males 1 female) SAMA, MSNV; Valery, A. P. M. *Eucalyptus* plantation, McMullen's Block, 30°24'S 152°57'E, light trap, R. S. McInnes 10.1.1967 (4) ANIC, MSNV; Windsor, A. M. Lea 1871, Griffith Coll. (17) SAMA, MSNV. **Northern Territory**: Jabiru 10 km SW, C. Watts 22.3.1998 (1) SAMA; Gubara 1 km W, Kakadu NP, C. Watts 17.3.1998 (1 male) SAMA. **Western Australia**: Fremantle 10 km S, C. Watts 24.10.1996 (1) SAMA.

Description

Length 1.6–1.9 mm; width 1.0–1.1 mm. Body convex, short oval (Figs 20, 21), entirely black, only tips of palps and legs reddish. Head shining, smooth, only occipital region alutaceous, evenly punctured, intervals between punctures large, nearly twice as large as the punctures. In frontal view one eye measures nearly 1/6 of interocular space. Pronotum black, shining, smooth, evenly punctured as on head; at 100 x bottoms of punctures are umbilicate or jutting. Anterior margin of pronotum protruding in centre and laterally; lateral margin arched so that posteriorly pronotum enlarges. Scutellum triangular, slightly elongate, with curved sides, faintly punctured. Elytra short, their maximum width at anterior third; punctures denser than on pronotum, at 100 x umbilicate or rugose, evenly distributed; surface slightly alutaceous between punctures; parasutural furrow on apical 2/3 or a bit less. Underside black. Labrum arched, slightly hollow at centre; postlabium flat or convex, alutaceous at 100 x with scarce and faint punctures. Gula alutaceous, with two furrows and two deep punctures. Prosternum tectiform, keeled; mesosternum with longitudinal keel anteriorly expanded; metasternum punctured and pubescent, elevated in centre, slightly hollow and posteriorly produced. Five visible abdominal sternites, micropunctured, not keeled; pygidium with a dozen stiff and short setae directed posteriorly and centrally. Profemora excavated, granulose and hairy on basal 2/3; mesofemora hairy on basal 3/4; metafemora smooth, with sparse hairs. Tibiae shorter than femora, spiny at their margins; tarsi not expanded in male, claws hooked. Aedeagus (Fig. 15) nearly 1/4 as long as body; tegmen shorter than parameres, narrow and pointed at base; parameres slender, with rounded apices; penis conical, pointed, without any collar.

Discussion

Characters of the species distinguishing it from all Australian *Paracymus* are the umbilicate punctures, the copious hydrofugal hairs at the base of the mesofemora (only *cariceti* has more), the lack of any keel on the first ventrite (as in *cariceti*, which however has a tubercle instead of a keel), and the aedeagus (penis triangular to the apex, tegmen abruptly pointed). From *pygmaeus* it is also separated by the small size, the short and convex body (length:width 1.7 in *pygmaeus;* 1.6 in *wattsi*). With *opacus, australiae* and *weiri* it constitutes a group of short and convex *Paracymus* (Figs 20, 21). Wooldridge 1978 records two females of this species (SAMA; now 1 in ANIC) as possibly belonging to the palaearctic *P. phalacroides* (Wollaston, 1867). But the punctures of *phalacroides* are geminate, not umbilicate as in *wattsi*; the mesosternal keel of *phalacroides* is very low, in *wattsi* normally

shaped; and the bases of the parameres are internally excavated in *phalacroides*, swollen in *wattsi*.

Biology

One label has the note: light trap. C. Watts captured his specimens 'in thick grassy vegetation at edge of water in large swampy areas' (personal communication).

7. *Paracymus opacus* n. sp.

Types (Fig. 25)

Holotype male (1.7 x 1.0 mm): **Queensland**, Bentinck Is. Minakuri, Aitken & Tindale 23.5.1960 at light, SAMA. *Paratypes*: **Queensland**: Bentinck Is. Minakuri, Aitken & Tindale 23.5.1960 at light (4) SAMA, MSNV; Paluma Dam Road, J. G. Brooks 13.1.1968 (1) ANIC; Seaforth 1 km NW, 20°53'S 148°57'E, A. Gillison 18.11.1981 Berlesate, Melaleuca woodland (1) ANIC; Stewart R., W. D. Dodd (3) SAMA, MSNV; Townsville 20 km N, Bushland Beach, A. J. Watts 6–11.2.1998 (2) SAMA.

Description

Length 1.6–2.0 mm; width 0.95–1.2 mm. Body convex, short, oval (Figs 20, 21), entirely black. Upper body entirely alutaceous, satiny, impunctate. Head grey-black, satiny like pronotum and elytra, branches of Y-suture conspicuous. Pronotum enlarged posteriorly. Scutellum triangular, impunctate. Elytra with parasutural furrow in apical 2/3 or a bit less. Underside black or dark brown; postlabium flat, alutaceous, impunctate; prosternum short, roof-like, with a longitudinal keel; mesosternal keel short, ending anteriorly close to a high transverse ridge; metasternum hairy, elevated in middle as a flat triangle posteriorly acute. First abdominal ventrite with a median keel, rising from a central process protruding anteriorly. Antennae 8-segmented; basal 2/3 of profemur densely pubescent, protibiae and protarsi short and thick, last tarsal segment with a small denticle in males; claws short and hooked. Aedeagus (Fig. 16) with a very long tegmen, penis rod-like, anchor-shaped at tip, parameres provided with a triangular membrane, progressively expanded from base to apex.

Discussion

Among Australian *Paracymus*, *opacus* differs in having a strongly alutaceous and impunctate upperside, a flat hairy triangular prominence on the metasternal surface, and a very unusual aedeagus: tegmen more than twice as long as the length of the parameres, which are expanded towards the penis by a membrane. It is very near *P. wattsi* in body form and size, but is easily separated by the preceding characters.

Biology

Four specimens captured at light, one from forest floor litter, with Berlese funnel.

8. *Paracymus australiae* n.sp.

Types (Fig. 25)

Holotype male (2.3 x 1.4 mm): **Northern Territory**: Oenpelli 6 km SW by S, 12°22'S 133°01'E, E. G. Matthews 30.5.1973 at light, ANIC. *Paratypes*: **Northern Territory**: Baroalba Spring, 12°47'S 132°51'E, 20.11.1972 (1) ANIC; Borroloola 46 km SSW, 16°28'S 136°09'E, J. E. Feehan 23.4.1976 (6) ANIC, SAMA, MSNV; Borroloola 48 km SW by S, McArthur R., 16°27'S 136°05'E, J. E. Feehan 13.4.1976 at light (1) ANIC; Cahills Crossing 1 km S, E Alligator R., 12°26'S 132°58'E, E. B. Britton 3.11.1972 at light (1) ANIC; Cape Crawford 8 km ESE, Bessie Spring, 16°40'S 135°51'E, M. S. Upton 26.10.1975 (1) ANIC; Mt Cahill 8 km E, Nourlangie Ck, 12°52'S 132°47'E, E. B. Britton 27.10.1972 at light (1) ANIC; Mt Cahill 15 km E by N, 12°50'S 132°51'E, E. B. Britton 29.10.1972 at light (4) ANIC, SAMA, MSNV; Mt Cahill 15 km E Koongarra, 12°52'S 132°50'E, M. S. Upton 15.11.1972 (5), 6–10.3.1973 (3) ANIC, SAMA, MNSV; Mudginbarry HS 9 km N by E, 12°31'S 132°54'E, Upton & Feehan 10.6.1973 (3) ANIC, SAMA, MSNV; Oenpelli 6 km SW by S, 12°22'S 133°01'E, Upton & Feehan 6.6.1973 (1) ANIC.

Description

Length 2.0–2.5 mm; width 1.35–1.5 mm; short, oval, slightly convex. Upper side black with dark testaceous contour zone; head, pronotum and elytra coarsely punctate, space between punctures nearly as large as punctures; each puncture larger than those of *P. pygmaeus*. Head entirely black, anteriorly slightly hollow in centre to receive labium; sutures not conspicuous; eyes large, together nearly 6/10 width of interocular space. Pronotum anteriorly slightly curved, with notably prominent corners, much larger at base (ratio hind width : fore width 1.65); black with brown sides, evenly punctured as on elytra. Elytra, observed from above, nearly as long as wide (ratio elytral

FIGURE 25. Distribution of the studied specimens of *Paracymus opacus* n. sp. (▲), *australiae* n. sp. (■), *weiri* n. sp. (●), and *ovum* n. sp. (♦).

length : elytral width 1.07); parasutural furrow in apical 3/4 or a bit less; black with brown sides and apex. Underside dark, brown to reddish; labrum of male with two small specula, postlabium flat, slight and shining; prosternum roof-like, with longitudinal keel; a fine mesosternal keel anteriorly reaches a robust crescent-shaped ridge; metasternum hairy, two reliefs provided with tufts of setae delimiting a central glabrous area; first abdominal ventrite keeled on anterior 1/2–1/3. Palps yellow, antennae 8-segmented; profemora hairy on basal 3/4, male protarsi with a robust seta or tooth; mesofemora with hydrofuge hairs on a large postero-basal area; metafemora glabrous. Aedeagus (Fig. 10) long, nearly 3/10 of body length, tegmen constricted near base, bluntly pointed, longer than parameres, these blunt at apices, penis nearly triangular, gradually narrower from base to apex, without any collar.

Discussion

Among the Australian *Paracymus*, some features are exclusive to *australiae*: the great length of the parasutural furrow, the coarse dorsal punctation with large punctures, the male specula, the two hairy metasternal reliefs, and the first ventrite, which is keeled only anteriorly. This species is distinguishable from *pygmaeus* also by the stocky body shape, and by the aedeagus being more slender, straightened basally, with penis gradually narrowing, not suddenly restricted in the apical zone, unprovided with a collar.

Biology

Some specimens were captured at light, others in standing or flowing water.

9. *Paracymus weiri* n. sp.

Types (Fig. 25)

Holotype male (2.9 x 1.7 mm): **Western Australia**: Carson Escarpment, 14°49'S 126°49'E, Common & Upton 9–15.8.1975 ANIC. *Paratypes*: **Western Australia**: Carson Escarpment, 14°49'S

126°49'E, Common & Upton 9–15.8.1975 (9) ANIC, SAMA, MSNV.

Description

Length 2.3–3.0 mm, width 1.5–1.8 mm; short oval, convex. Head black, evenly punctured, interspaces smooth, nearly as large as punctures; anteriorly a central hollow receives labrum; eyes slightly protuberant, their width together nearly 2/3 of interocular space; Y-suture reduced to an incomplete periocular groove. Pronotum and elytra black with lateral margins and apex testaceous-reddish, punctured as on head or more deeply; elytra with parasutural furrow in apical 2/3 or a bit less; scutellum triangular, slightly elongate, punctured. Underside dark. Postlabium flat and smooth; prosternum evidently keeled; mesosternum with a longitudinal keel ending anteriorly as an arrow-head; metasternum glabrous in centre, the glabrous area delimited by two hairy lines converging posteriorly. First abdominal ventrite with a high keel almost reaching posterior margin. Palps and antennae (8-segmented) yellow with dark tips; legs dark; profemur pubescent nearly to the knees, last segment of male protarsi with two little teeth; mesofemora pubescent for nearly 2/3 of posterior margin. Aedeagus as in Figs 13, 14: tegmen concave at base, longer than parameres; these blunt at apices; penis conical, stout, provided with a preapical expansion or collar.

Discussion

Considering the body shape, *P. weiri* belongs to the group containing *wattsi*, *opacus*, and *australiae* (Figs 20, 21); the outline of the aedeagus recalls *P. ovum*. The body shape and upper punctation are similar to *P. australiae*, but *weiri* is larger in size and not provided with male specula; it has the first abdominal ventrite with a high keel and a very different aedeagus: base of tegmen concave (in *australiae* bluntly pointed), penis abruptly expanded before the apex (in *australiae* uniformly conical).

A Key To The Australian *Paracymus*

1. — Elytral colour mahogany or testaceous brown; pronotum black. Aedeagus as in Figs 6–8: tegmen pointed at base, penis with a simple preapical collar, external border of parameres evenly curved. Elongate oval (Figs 18, 19). Length 1.5–2.3 mm .... *spenceri* Blackburn

— Pronotum and elytra black. Aedeagus with different combination of characters: base of tegmen concave, or penis without a simple preapical collar, or parameres externally straight 2

2. — Male protarsus swollen, last segment evidently thicker than in female, proclaws spatulate, inner one stronger than outer. Aedeagus as in Figs 1–5: base of tegmen pointed, penis with a preapical collar originating a basal membrane, parameres externally straight. Elongate oval (Figs 18, 19). Length 1.6–3.0 mm .... *pygmaeus* (McLeay)

— Male protarsus not or only a bit swollen. Aedeagus without a preapical collar originating a membrane 3

3. — Upper side impunctate and strongly alutaceous, satiny. Aedeagus as in Fig. 16: a very long tegmen (more than 2 x the length of parameres), penis rod-like, anchor shaped at apex, parameres internally originating as a membrane. Short oval, convex (Figs 20, 21). Length 1.6–2.0 mm ..... *opacus* n. sp.

— Upper side punctured, smooth or moderately alutaceous. Tegmen shorter, parameres without any membrane 4

4. — Dorsal punctures (magnification 100 x) umbilicate or with a jut in the bottom. First abdominal ventrite not keeled nor tuberculate. Short, widely oval, convex (Figs 20, 21). Aedeagus as in Fig. 15: tegmen sharply pointed, penis conical, without any collar. Length 1.6–1.9 mm. ..... *wattsi* n. sp.

— Dorsal punctures simple, not umbilicate. First abdominal ventrite keeled or tuberculate. Tegmen never sharply pointed 5

5. — Antennae 9-segmented. Maxillary palps long, 0.6 x width of head. Dorsal surface slightly shagreened. Metasternum with a conspicuous triangular dimple. Aedeagus as in Figs 11, 12: tegmen provided with a central jut covering the base of the penis. Length 3.0 mm ..... *gigas* Gentili

— Antennae 8-segmented. Maxillary palps shorter than 0.5 x the width of head. Metasternum without any dimple. Tegmen simple, without any jut anteriorly protruding 6

6. — Parasutural furrow covering nearly 3/4 of elytral length. Upper side coarsely punctured with large punctures. Male labrum with small specula. Only anterior 1/2–1/3 of the first ventrite keeled. Aedeagus as in Fig. 10: base of tegmen bluntly pointed, penis simply conical. Length 2.0–2.5 mm ..... *australiae* n. sp.

— Parasutural furrow covering nearly 2/3 of elytral length. Labrum without specula. First ventrite not or differently keeled. Apex of penis anchor-shaped 7

7. — Whole ventral surface of mesofemora pubescent. First ventrite tuberculate along the median line. Aedeagus bluntly pointed at base, penis with apical anchor, apices of parameres acute (Fig. 9). Length 1.7–1.8 mm ..... *cariceti* n. sp.

— At least apical 1/3 of mesofemora glabrous. First ventrite keeled. Aedeagus concave at base, penis with preapical expansion, apices of parameres blunt 8

8. — First ventrite completely carinate with a flat longitudinal keel. Dorsal punctures more feeble. Elongate oval (Figs 18, 19). Aedeagus as in Fig. 17: tegmen nearly as long as parameres, penis more thin, rod-like, with feeble preapical expansions. Length 2.5–2.8 mm ..... *ovum* n. sp.

— First ventrite with a high keel not covering whole segment. Dorsal punctures stronger. Short oval (Figs 20, 21). Aedeagus as in Figs 13, 14: tegmen longer than parameres, penis more stout, subconical, with strong preapical expansions. Length 2.3–3.0 mm ..... *weiri* n. sp.

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References

BLACKBURN, T. 1888. Notes on Australian Coleoptera with descriptions of new species. *Proceedings of the Linnaean Society of New South Wales* (2) **3** (1889): 805–875.

BLACKBURN, T. 1891. Further Notes on Australian Coleoptera, with Descriptions of New Genera and Species. *Transactions of the Royal Society of South Australia* **14**: 65–153.

BLACKBURN, T. 1894. Further Notes on Australian Coleoptera, with Descriptions of New Genera and Species. *Transactions of the Royal Society of South Australia* **18**: 139–168; 200–204.

BLACKBURN, T. 1896. Coleoptera (exclusive of the Carabidae). Pp. 254–308 *in* 'Report on the work of the Horn Scientific Expedition to Central Australia', Part II, Zoology. Ed. B. Spencer. Dulau & Co.: London; Melville, Mullen & Slade: Melbourne.

BLACKBURN, T. 1899. Notes on Australian Coleoptera with descriptions of new Species. *Proceedings of the Linnaean Society of New South Wales* (2) **3**: 805–875.

BROUN, T. 1880. Manual of the New Zealand Coleoptera. Government Printing Office: Wellington. Vol. I, pp. 1–651.

FAUVEL, A. 1883. Les Coléoptères de la Nouvelle Calédonie et Dépendences avec descriptions, notes et synonymies nouvelles. *Revue Entomologique de Caen* **2**: 335–360.

GENTILI, E. 1992. The *Notohydrus* of Australia. *Bollettino della Società Entomologica italiana* **124** (1): 21–26.

GENTILI, E. 1993. *Paranacaena* Blackburn, 1889: a valid genus. *Giornale Italiano di Entomologia* **6**: 285–296.

GENTILI, E. 1996. Notes on the Anacaenini from Australia and Melanesia with descriptions of new species. *Giornale Italiano di Entomologia* **8**: 177–189.

HANSEN, M. 1991. The Hydrophiloid Beetles. Munksgaard: Copenhagen, pp. 1–367.

HANSEN, M. 1999. Hydrophiloidea. *In:* 'World Catalogue of Insects 2'. Apollo Books: Stenstrup, pp. 1–416.

KNISCH, A. 1924. Hydrophilidae. *In* 'Coleopterorum Catalogus, 79'. Ed. W. Junk. Winkler: Berlin, pp. 1–278.

MACLEAY, W. 1871. Notes on a collection of Insects from Gayndah. *Transactions of the Entomological Society of New South Wales* **II** (1873): 79–205.

MATTHEWS, E. G. 1982. A guide to the Genera of Beetles of South Australia (2). South Australian Museum Publications: Adelaide, pp. 1–64.

McKEOWN, K. C. 1948. A reference list of types of Coleoptera in the Australian Museum. *Records of the Australian Museum* **22**: 95–139.

ORCHYMONT (D'), A. 1926. Notes on Philippine Hydrophilidae. *Philippine Journal of Science* **30**: 361–385.

ORCHYMONT (D'), A. 1937. Check list of the Palpicornia of Oceania. *Occasional Papers of the Bernice P. Bishop Museum* **13**: 147–160.

ORCHYMONT (D'), A. 1942. Contribution à l'étude de la tribu Hydrobiini Bedel, spécialement de sa sous-tribu Hydrobiae. *Mémoires du Musée Royal d'Histoire Naturelle de Belgique* **2** (24): 1–68.

SHARP, D. S. 1884. Revision of the Hydrophilidae of New Zealand. *Transactions of the Entomological Society of London* **4**: 465–480.

WHITE, F. 1871. Hydrophilidae. Pp. 1–64 *in* 'Catalogue of the described Coleoptera of Australia', 1. Ed. G. Masters. Sydney.

WINTERBOURN, M. J. 1970. The Hydrophilidae (Coleoptera) of New Zealand's Thermal Waters. *Transactions of the Royal Society of New Zealand (Biological Sciences)* **12**: 21–28.

WOOLDRIDGE, D. P. 1976. *Paracymus* of the Australian faunal Region. *Journal of the Kansas Entomological Society* **49** (3): 453–462.

WOOLDRIDGE, D. P. 1978. *Paracymus* of the Palearctic faunal Region. *Journal of the Kansas Entomological Society* **51** (1): 123–130.

WOLLASTON, T. V. 1867. Coleoptera Hesperidum, being an enumeration of the Coleopterous insects of the Cape Verde Archipelago. J. V. Voorst: London, pp. 1–285.

ZAITZEV, F. A. 1908. Catalogue des Coléoptères aquatiques des familles Dryopidae, Georyssidae, Cyathoceridae, Heteroceridae et Hydrophilidae. *Horae Societatis Entomologicae Rossicae* **38**: 283–420.

A NEW SPECIES OF THE GENUS *LESTIGNATHUS* ERICHSON FROM TASMANIA WITH A NOTE ON THE TASMANIAN SPECIES OF *MECYCLOTHORAX* SHARP (INSECTA: COLEOPTERA: CARABIDAE: LICININAE, PSYDRINAE)

MARTIN BAEHR

BAEHR, M. 2000. A new species of the genus *Lestignathus* Erichson from Tasmania, with a note on the Tasmanian species of *Mecyclothorax* Sharp (Insecta: Coleoptera: Carabidae: Licininae, Psydrinae). *Records of the South Australian Museum* 33(2): 123–126.

Lestignathus pieperi, sp. nov. is described from Mt Field, southwestern Tasmania. It is distinguished *inter alia* from the three known species of the genus *Lestignathus* by presence of only one setiferous puncture on the 3rd interval. A key to all species of the genus is added.

Recent collections revealed that in Tasmania two species of *Mecyclothorax* occur, namely the well-recorded *M. ambiguus* (Erichson), and *M. punctipennis* (Macleay) that is widespread on the mainland but not previously recorded from Tasmania.

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Introduction

Through the kindness of Dr Harald Pieper (Kiel) I received a sample of Tasmanian Carabidae for identification that he collected mainly in western Tasmania during a trip in December 1998. This sample included, *inter alia*, a new species of the licinine genus *Lestignathus* Erichson, as well as the first Tasmanian record of the psydrine species *Mecyclothorax punctipennis* (Macleay). By courtesy of Dr Eric Matthews, Adelaide, I had the opportunity to compare types or material of all described species of *Lestignathus* stored in the collection of the South Australian Museum.

So far, the genus *Lestignathus* Erichson includes three rather different species (Sloane 1920, Moore *et al.* 1987) that all occur in Tasmania, namely the common and widespread, large *Lestignathus cursor* Erichson, and the apparently much rarer, smaller species *L. foveatus* Sloane and *L. simsoni* Bates. The new species differs from all described species in several respects, hence description of the single known specimen seems advisable, the more so as all species of *Lestignathus*, except for *L. cursor*, apparently are rare or very rare, and additional material is unlikely to be detected soon.

Measurements

Measurements have been made under a stereo microscope by use of an ocular micrometer. Length has been measured from apex of labrum to apex of elytra. Length of pronotum was taken from the most advanced tip of anterior angles to the most advanced part of base. Width of base was taken at position of the posterior marginal setae. Measurements, therefore, may slightly differ from those of Sloane (1920).

Location Of Types

To facilitate further study of the genus *Lestignathus*, the holotype of *L. pieperi* sp. nov. is presented to the South Australian Museum. Therefore, the types of three of the four recorded species of the genus *Lestignathus* are assembled in that collection which also holds historical material of the fourth species.

Lestignathus pieperi sp. nov.

(Figs 1–2)

Holotype: f, TAS, Mt Field Lyrebird Nat. Walk 30.11.1998 leg. H. Pieper (SAMA).

Diagnosis

Distinguished from all other species of the genus *Lestignathus* by presence of only 1 setiferous puncture on 3rd elytral interval. Further distinguished from *L. cursor* Erichson by much lesser size; from both, *L. foveatus* Sloane and *L. simsoni* Bates, by less cordate, anteriorly much

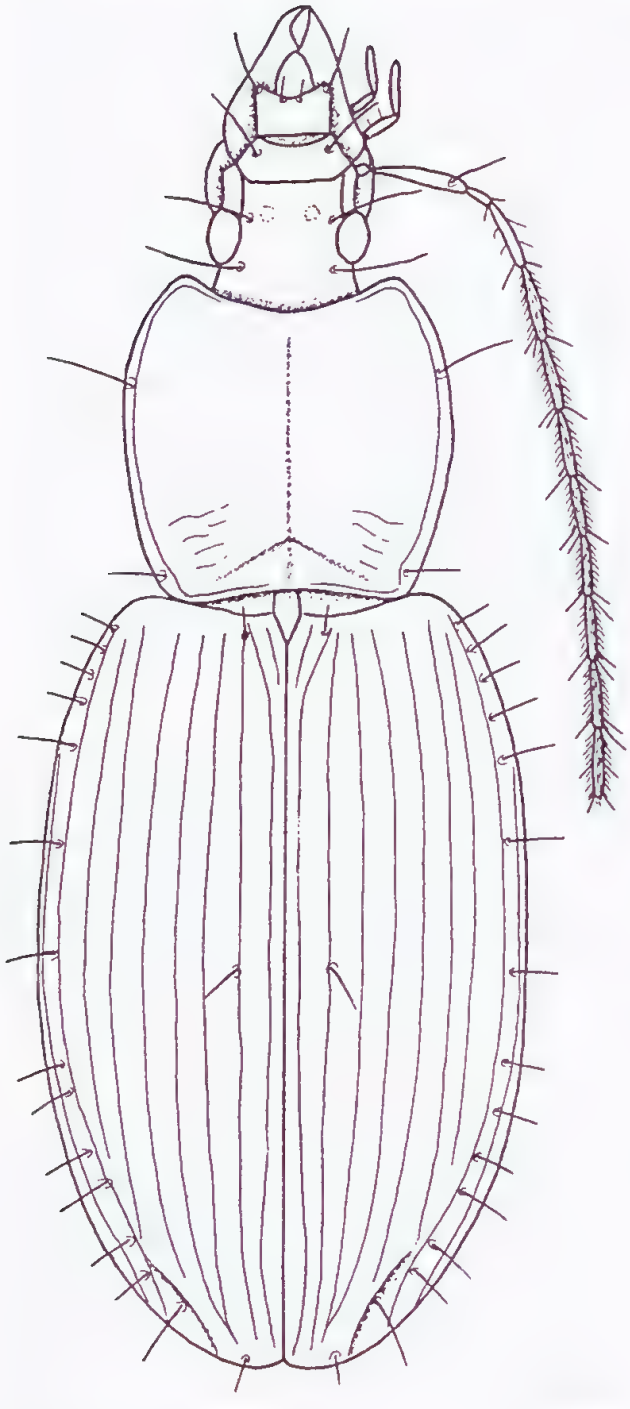

FIGURE 1. *Lestignathus pieperi* sp. nov. Habitus. Length: 7.55 mm.

narrower pronotum, almost completely depressed elytral intervals, and narrower head which is less than half as wide as pronotum; and from latter species also by slightly lesser size.

Description

Measurements. Length: 7.55 mm; width: 3.0 mm. Ratios: width/length of pronotum: 1.06; width base/apex of pronotum: 1.37; width pronotum/head: 2.08; length/width of elytra: 1.59; width elytra/pronotum: 1.52.

Colour. Piceous-black, pronotum and elytra with narrow reddish margins; labrum and mouthparts red, clypeus reddish-piceous, basal and apical antennomeres reddish, median antennomeres piceous, femora and tibiae in middle reddish-piceous, basally and apically lighter, tarsi light reddish. Lower surface black.

Head. Very small in comparison to prothorax. Eyes large though laterally little produced, with small orbits. Clypeus bisetose, anterior central part of clypeus membranous. Labrum medially deeply, symmetrically v-shaped, excised for about a third of its length, quadrisetose. Mentum with an indistinct, slightly triangular tooth, ligula bisetose, glossa and paraglossae of about equal length. Lacinia with elongate tooth at end, median border with dense fringe of stiff setae. Palpi rather slender and elongate, apical palpomeres thickened, both terminal palpomeres extremely sparsely pilose. Both mandibles bidentate, though lower tooth of right mandible more acute than that of left mandible, therefore apical excision in right mandible about quadrate, in left mandible more semicircular. Clypeofrontal suture very shallow, straight. Frons convex, near clypeal suture with shallow, rather irregularly shaped impression on either side. Both supraorbital pores very large. Frons impunctate, with distinct, isodiametric microreticulation. Antenna slender and elongate, surpassing anterior third of elytra, median antennomeres > 4 x as long as wide, two basal antennomeres glabrous, 3rd antennomere sparsely pilose, the following antennomeres densely pilose.

Prothorax. Slightly wider than long, laterally fairly convex, more than twice as wide as head, widest slightly in front of middle. Apex in middle deeply excised, anterior angles prominent, at apex rounded off. Lateral margin in basal half almost straight. Base distinctly concave in middle, basal angles widely rounded off. Apex and lateral borders with narrow though distinct margin, base in middle not margined. Median line distinct though shallow, almost complete. Anterior and posterior transverse impressions barely indicated. Basal impressions large, wide, with an elongate, linear impression in median part. Disk rather depressed, near basal angles widely explanate, rather even. Disk without any wrinkles or punctures, with distinct, more or less isodiametric microreticulation. Anterior marginal seta situated slightly behind anterior third, well in front of widest diameter, slightly removed from margin. Posterior marginal seta situated a short distance in front of basal angle, close to margin.

Elytra. Elongate-ovalish, widest about at

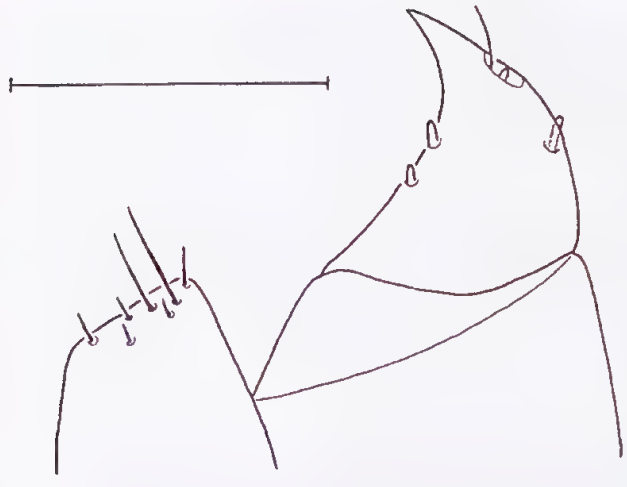

FIGURE 2. *Lestignathus pieperi* sp. nov. Female stylomere 2 and base of stylomere 1. Scale line: 0.25 mm.

middle, surface moderately convex, considerably wider than prothorax. Humeri barely projecting, basal and lateral margins meeting without any angle. Lateral margin evenly rounded to apex, slightly incurved at the very tip. Striation complete, striae well impressed, very faintly crenulate, intervals gently convex. Scutellar stria elongate, scutellar pore present. 3rd interval with a setiferous puncture in about middle, puncture attached to 2nd stria. Marginal series consisting of 13–14 large punctures that are more widely spaced in middle. Two additional punctures situated preapically and apically at 7th stria. Intervals impunctate, with highly superficial, transverse microreticulation, rather glossy. Wings reduced.

Lower surface. Impunctate. Metepisternum about as long as wide. Terminal abdominal sternite in female with 4 setae on either side.

Legs. Slender and elongate. Structure of male anterior tarsus unknown. Metatibia almost straight. Metatarsus very slender. 5th tarsomeres of all legs slender, lower surface setulose.

Male genitalia. Unknown.

Female genitalia (Fig. 2). Both stylomeres markedly depressed, foliaceous. Stylomere 2 short and wide, triangular, with short, acute apex, laterally with 2 very short latero-ventral ensiform setae, mediodorsally with a moderately short dorso-medial ensiform seta, on median rim near apex with a nematiform seta originating in a large groove. In middle of the groove with a small tubercle. Apex of stylomere 1 without any setae. Lateral plate conspicuously triangular at apex, with a 2–3 elongate and some very short nematiform setae at apical rim.

Variation. Unknown.

Distribution. Mt Field, southwestern Tasmania. Known only from type locality.

Collecting circumstances. Collected on the ground in temperate rain forest. The holotype was captured together with *Lestignathus cursor* Erichson.

Etymology. The name is a patronym in honour of the collector Dr Harald Pieper.

Relationships

The sparsely setulose 3rd antennomere and the presence of both marginal pores on the pronotum place this species in the genus *Lestignathus* Erichson, although externally it resembles species of the related genus *Lacordairia* Castelnau.

Because the male genitalia of this species are not yet known and two of the three other species of *Lestignathus* are apparently very rare, nothing can be said about relationships of this species, which is unique within the genus by the presence of a single elytral puncture only. Certainly, all species of the genus differ remarkably in certain external characters.

KEY TO THE SPECIES OF *LESTIGNATHUS* ERICHSON

1. — Size larger, body length >12.5 mm; elytra with 2 non-foveate punctures, at apex not deeply sinuate ..... *cursor* Erichson
   — Size smaller, body length <10 mm; elytra either with foveate punctures, or with 1 puncture only, or at apex deeply sinuate 2
2. — Each elytron with 3–4 foveate punctures .. .. *foveatus* Sloane
   — Each elytron with at most 2 non-foveate punctures 3
3. — Size larger, body length >9 mm; each elytron with 2 setiferous punctures, apex of elytra deeply sinuate ..... *simsoni* Bates
   — Size smaller, body length c. 7.5 mm; each elytron with 1 setiferous puncture, apex of elytra barely sinuate ..... *pieperi* sp. nov.

***Mecyclothorax punctipennis* (Macleay)**

Moore 1984: 162; Moore *et al.* 1987: 149.

The material collected recently by H. Pieper in Tasmania includes a male specimen of *Mecyclothorax punctipennis* (Macleay) besides

specimens of the well known *M. ambiguus* (Erichson). The identity of *M. punctipennis* has been confirmed by dissection of the male genitalia and by comparsion with genitalia of the Tasmanian *M. ambiguus*, moreover by comparison with the figures in Moore (1984). Data for this specimen are: TAS, Rocky Cape NP, 22.11.1998, leg. H. Pieper.

This is the first Tasmanian record of this species which is common and widespread on the mainland (Moore *et al.*1987).

Acknowledgments

My sincere thanks are due to Dr H. Pieper (Kiel) for kindly submitting his interesting material for identification, and to Dr E. Matthews (Adelaide) for the kind loan of types and material for comparison.

References

MOORE, B. P. 1984. Taxonomic notes on some Australian *Mecyclothorax* Sharp (Coleoptera: Carabidae: Psydrinae) and description of new species. *Journal of the Australian Entomological Society* **23**: 161–166.

MOORE, B. P., WEIR, T. A. & J. E. PYKE. 1987. Rhysodidae and Carabidae. In: Zoological Catalogue of Australia, **4**: 17–320. Australian Government Publishing Service: Canberra.

SLOANE, T. G. 1920. The Carabidae of Tasmania. *Proceedings of the Linnean Society of New South Wales* **45**: 113–178.

SIX NEW SPECIES OF *NIRRIDESSUS* WATTS AND HUMPHREYS AND *TJIRTUDESSUS* WATTS AND HUMPHREYS (COLEOPTERA: DYTISCIDAE) FROM UNDERGROUND WATERS IN AUSTRALIA

C. H. S. WATTS AND W. F. HUMPHREYS

WATTS, C. H. S. and HUMPHREYS, W. F. 2000. Six new species of *Nirridessus* Watts and Humphreys and *Tjirtudessus* Watts and Humphreys (Coleoptera: Dytiscidae) from underground waters in Australia. *Records of the South Australian Museum* **33**(2): 127–144.

Six new species (*Nirridessus bigbellensis, N. cueensis, N. hinkleri, N. morgani, Tjirtudessus hahni* and *T. magnificus*) of stygobiontic beetles of the family Dytiscidae, subfamily Hydroporinae, tribe Bidessini, from relatively shallow, calcrete aquifers in Western Australia, are described and figured. The species are members of a diverse, recently discovered, relictual stygofauna, predominantly of Crustacea and Oligochaeta, inhabiting calcretes lying along palaeodrainage channels. The two genera occur in palaeochannel deposits on either side of the divide between the inland and Indian Ocean drainages. Each calcrete area contains a distinct assemblage of beetles and the fauna occurs in both fresh and saline groundwater. The physico-chemical properties of the groundwater, and the palaeogeography and hydrology of the region are discussed in some detail.

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Stygobiotic water beetles have been reported from a number of widely scattered localities around the world (Spangler 1986) but it was not until 1999 that they were first reported from Australia (Watts and Humphreys 1999). These belonged to the Dytiscidae and were discovered living in relatively shallow calcrete aquifers in the Lake Way/Lake Carey palaeodrainage system of Western Australia. Five species in three genera in the tribe Bidessini were involved.

These groundwater calcretes are restricted to the arid parts of Australia (Fig. 40) where the potential evaporation exceeds rainfall by more than an order of magnitude (detailed in Humphreys 1999; Watts and Humphreys 1999).

In May 1999 one of us (W.F.H.) spent some time investigating other areas of inland palaeodrainage in Western Australia with groundwater calcretes and discovered additional stygofaunas which included dytiscids.

In this paper we describe the six species of Dytiscidae collected and record the existence of a further two, all belonging to two of the original genera: *Tjirtudessus* and *Nirridessus*. We also give details of the physico-chemical properties of the water in the aquifers and the palaeogeography and hydrology of the region.

Methods

About 120 sites were sampled, comprising pastoral wells and boreholes constructed for water abstraction, groundwater investigation and mineral exploration in a number of fractured rock, alluvial and groundwater calcrete aquifers from the central Yilgarn Craton of Western Australia (Fig. 38). The beetles and associated fauna were taken by plankton nets hauled through the water column of the bores and wells, or sometimes from baited traps.

Physico-chemical parameters in the water were determined either *in situ*, or in a sample taken near the surface using a bailer, using electronic instruments—pH using a WTW pH 320 meter with a SenTix 97T pH combined electrode with integrated temperature sensor and redox probe, and dissolved oxygen using a WTW Oxi 320 meter and a CellOx 325 oxygen sensor (Wissenschaftlich-Technisch Werkstatten GmbH, Weilheim, Germany). Conductivity was measured with a TPS Model LC 84 conductivity meter (TPI Electronics, Springwood, Queensland, Australia). All were calibrated as specified using the recommended standards. In some samples the salinity was determined using a hand refractometer (Atago S-10e).

Abbreviations used

BES Prefix for field numbers, WAM Biospeleology.

OB Observation bore.

PAT Prefix, observation bore number, Austin Downs Borefield, Big Bell Mine.

SB Prefix, piezometer number in Hinkler Well calcrete to the west of Lake Way.

TPB Prefix, piezometer number in Hinkler Well calcrete to the west of Lake Way.

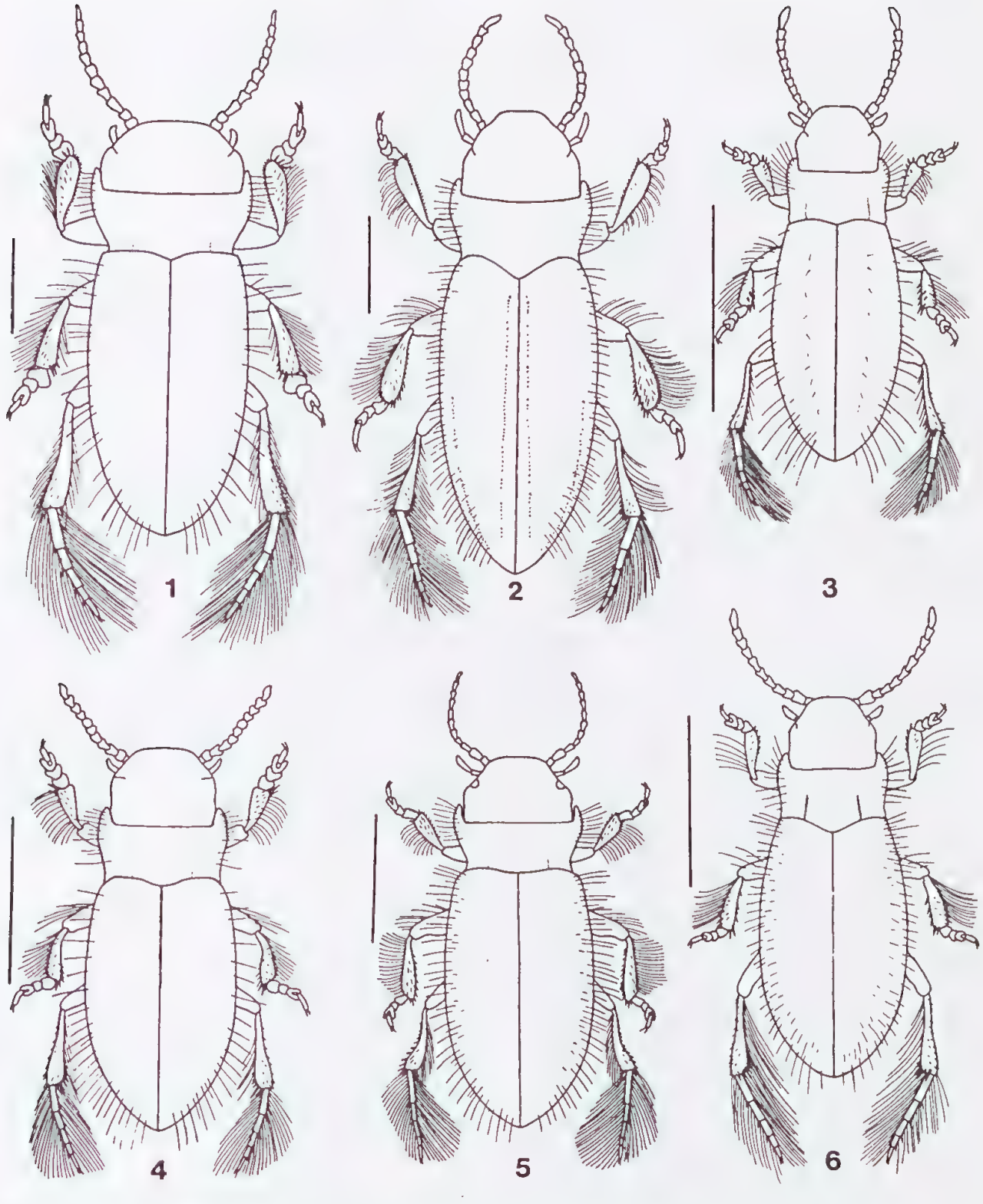
SAMA South Australian Museum, Adelaide.

WAM Western Australian Museum, Perth.

Systematics

Key To Australian Species Of Stygobionic Bidessini

1. — Body length <1.2 mm, dorsal surface strongly reticulate, legs stout, without swimming-hairs on fore and midlegs ..... *Kintingka kurutjutu* Watts & Humphreys
   — Body length >1.2 mm, dorsal surface with weak to moderate reticulation, legs normal, all legs with swimming hairs 2
2. — Pronotum usually wider than elytra (Fig. 1); third and fourth (apical) segments of labial palpi subequal in length (Figs 23–25); setae on hind edge of mesofemur not greatly different in robustness from those on mesotrochanter (Figs 10, 19, 20). Length > 3.0 mm ..... (*Tjirtudessus*) 9
   — Pronotum same width or narrower than elytra (Figs 3–6); third segments of labial palpi half to two thirds length of apical (Figs 26–32); setae on hind edge of mesofemur near base much more robust than those on mesotrochanter or elsewhere on femur (Figs 7–9). Length 1.0–3.2 mm .... (*Nirridessus*) 3
3. — Pronotal plicae well marked 4
   — Pronotal plicae difficult to trace 5
4. — Length of metatarsal segments 1 & 2 > segments 3 & 4; eye remnant present; parameres with long apical lobe .... *N. pulpa* Watts & Humphreys
   — Length of metatarsal segments 1 & 2 = < segments 3 & 4; without eye remnant; parameres with small apical lobe (Fig. 33) ..... *N. morgani* sp. nov.
5. — Length => 3.0 mm; eye remnant present (Fig. 5); group of six spines close to base of mesofemur on hind edge (Fig. 11) .... *N. bigbellensis* sp.nov.
   — Length =< 2.5 mm; with or without eye remnant; spines on mesofemur spread out along hind edge or, if restricted to base, four or fewer (Figs 8, 9, 13, 15) 6
6. — Pro- and mesotarsi broad (Fig. 4); segments two and three of antennae similar in shape; apical lobe of paramere overlies part of rest of paramere (Fig. 34) .... *N. cueensis* sp.nov.
   — Pro- and mesotarsi only weakly expanded (Fig. 3); segments two and three of antennae different in shape, second broad and rounded, third narrow and triangular; apical lobe of paramere well separated from rest of paramere (Fig. 35) 7
7. — Elytron without subsutural row of punctures; metatrochanters bluntly pointed (Fig. 14); length approximately 1.5 mm; median lobe of aedeagus truncated (Fig. 35) .... *N. hinkleri* sp.nov.
   — Elytron with row of large subsutural punctures; metatrochanters rounded; length up to 2.5mm; median lobe of aedeagus pointed 8
8. — Length 2.2–2.3 mm; with eye remnant..... .. *N. windarraensis* Watts & Humphreys
   — Length 1.3–1.5 mm; without eye remnant ..... *N. lapostaae* Watts & Humphreys
9. — Pro- and mesotarsi strongly expanded (Fig. 1); apical five segments of antennae noticeably thinner than others (Fig. 1) ... . *T. magnificus* sp. nov.
   — Pro- and mesotarsi only moderately expanded (Fig. 2); apical five segments of antennae not narrower than others (Fig. 2) 10
10. — Length > 4.0mm; median lobe of aedeagus twisted, tip knobbed (Fig. 37); without eye remnant; pronotum at its base a little narrower than elytra (Fig. 2) .... *T. hahni* sp. nov.
    — Length < 4.0mm; median lobe of aedeagus not twisted, tip pointed; with small eye remnant; pronotum at its base wider than elytra .... *T. eberhardi* Watts & Humphreys



FIGURES 1–6. **1**, Dorsal view of *Tjirtudessus magnificus*; **2**, ditto *T. hahni*; **3**, ditto *Nirridessus hinkleri*; **4**, ditto *N. cueensis*; **5**, ditto *N. bigbellensis*; **6**, ditto *N. morgani*. Scale bar = 1mm.

Tjirtudessus Watts & Humphreys, 1999

Tjirtudessus magnificus sp. nov.

Types

Holotype: m. 'BES 7040, Old Cue water supply bore, 27°16'10"S, 117°59'23" E, 12/5/99, coll W. F. Humphreys & H. J. Hahn', in spirit, WAM, registration number 26840.

Paratype: f. BES 7066, same data as for holotype except 13/5/99, SAMA.

Description (number examined, 2) Figs 1, 19, 20, 25, 36.

Habitus: Length 4.7–4.8 mm.; relatively flat, strongly constricted at junction of pronotum/ elytra; uniformly light testaceous; hindwing vestigial, about half length of elytron (Fig 1).

Head: Large, nearly as wide as elytra; smooth, reticulation very fine, punctures sparse, weak; subparallel in posterior half; sides with dark suture in middle near anterior edge. Antenna relatively stout, basal two segments cylindrical, third segment longer and narrower at base, next three subequal, next four progressively thinner, apical segment a bit longer and much narrower than penultimate, each segment with some very small setae on inside apically (Fig. 1). Maxillary palpus thin, elongate, apical segment large, a little shorter than segments one to three combined, three long setae on outer side and some sensillae towards tip, tip truncated. Labial palpus moderate, apical two segments subequal, tip weakly bifid, penultimate segment with small papilla near tip bearing two setae (Fig. 25).

Pronotum: Very broad, wider than elytra (Fig. 1); anterolateral angles projecting strongly forward; base quite strongly narrowed, posterolateral angles acute; smooth, with sparse, very weak punctures and a row of stronger punctures along front margin; basal plicae weak, reaching to about half way along pronotum, slightly excavated inwards; with row of long setae laterally, denser towards front.

Elytra: Not fused, lacking inner ridges; elongate, widest behind middle, smooth, quite densely and evenly covered with very small punctures, row of widely spaced larger punctures close to inner edge; lacking setiferous micropunctures; row of long setae near lateral edge, a few additional larger punctures with long setae, more frequent towards sides. Epipleuron broad in anterior fifth, then rapidly narrowing to be virtually absent over rest of elytron.

Ventral surface: Prothoracic process relatively broad, strongly narrowed between coxae, not reaching mesothorax, apical half spatulate, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae in contact at midline. Metathorax sharply triangular in front in midline, wings very narrow, broadly rounded in midline behind. Metacoxal plates large, metacoxal lines short, weak, widely spaced, reaching to about halfway to metasternum, diverging in anterior two-thirds; moderately covered with small setae-bearing punctures; closely adpressed to first abdominal ventrite. First and second ventrites fused, sutural lines distinct, ventrites three to five mobile, moderately covered with small seta-bearing punctures, ventrites three and four with a long central seta or bunch of long setae.

Legs: Protibia relatively narrow, inner edge straight, outer edge bowed, widest past middle where it is about three times its basal width; protarsi greatly expanded, first segment very broadly oval, second segment broad about one third length of first, third segment as long as first but much narrower and very deeply bifid, fourth segment very small and hidden within lobes of third segment, apical segment narrow, cylindrical, about length of third, segments one to three with very dense covering of adhesive setae; claws short and simple. Mesotrochanter rounded with row of setae on inner edge; mesofemur with row of 10–12 relatively weak setae along hind edge in basal half (Fig.19); mesotarsi similar to protarsi. Metatrochanter weakly pointed (Fig. 20); metafemur elongate, lacking spines; metatibia strongly curved, widening towards apex; metatarsi elongate, basal segment longest, apical segment a little longer than fourth, segments one and two in combination about as long as others; claws weak.

Male: Antennae a little stouter; pro- and mesotarsi a little stouter. Median lobe of aedeagus narrow, narrowing rapidly in apical quarter; paramere broad, apical segment with pronounced, narrow, apical lobe (Fig. 36).

Etymology

The species is named in reference to its appearance.

Remarks

A very large broad flat *Tjirtudessus* readily recognised by the large round first segment of the pro- and mesotarsi of both sexes, and the distinctive antennae with the apical segments noticeably narrower than the middle segments.

Tjirtudessus hahni sp. nov.

Types

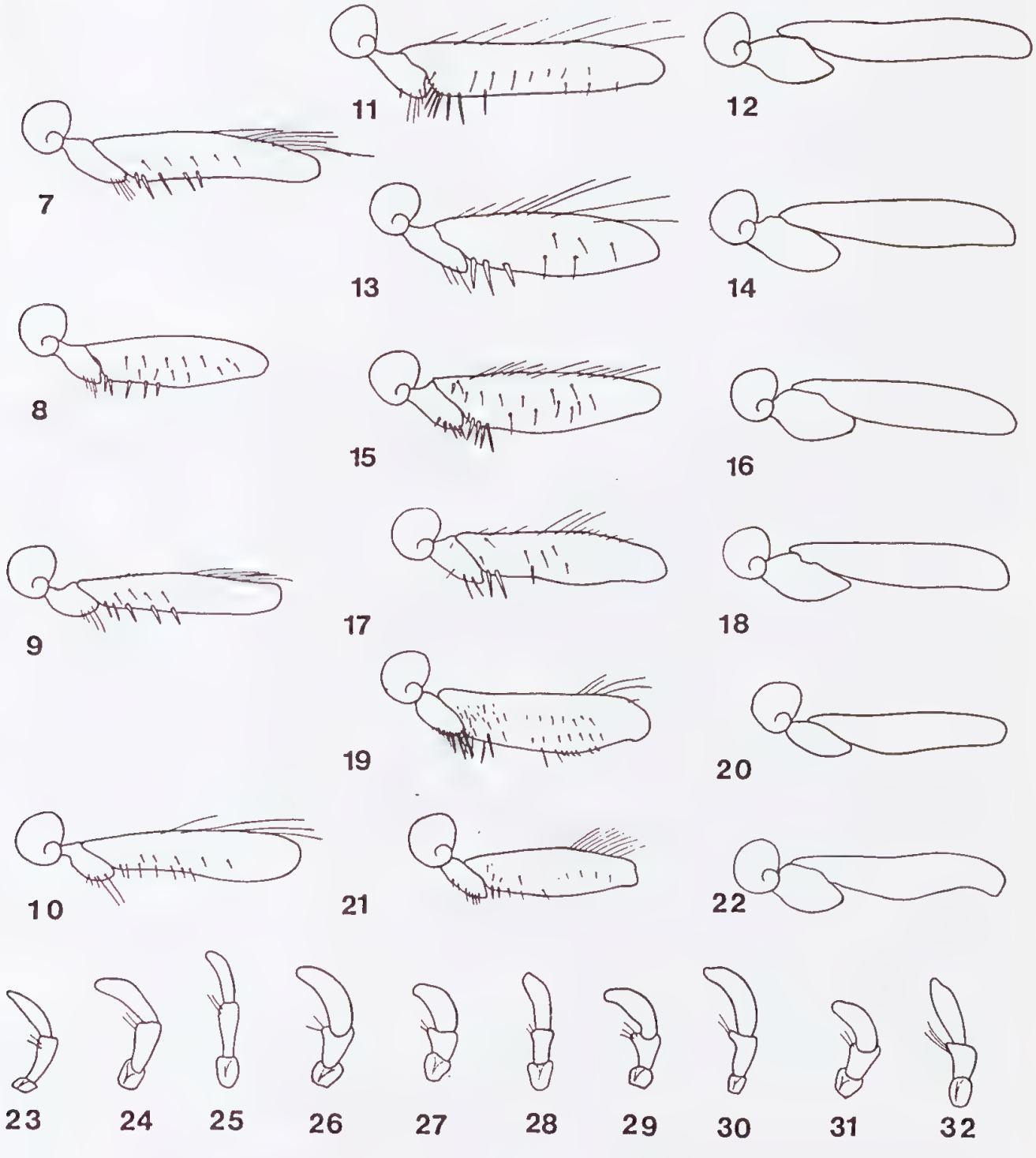
Holotype: m. 'BES 7197, mineral exploration bore, 26°41'16"S, 120°17'52"E, 21/5/99, coll. W. F. Humphreys & H. J. Hahn', slide mounted, WAM, registration number 26887.

Paratypes: 4; same data as holotype, most incomplete, 2 slide mounted, SAMA, 2 in spirit, WAM, registration numbers 26841, 26842.

Description (number examined, 5) Figs 2, 21, 22, 24, 37.

Habitus: Length 4.8 mm.; relatively flat, strongly constricted at junction of pronotum/elytra; uniformly light testaceous; hindwing vestigial, about one-third length of elytron (Fig. 2).

Head: Large, smooth, reticulation very fine, punctures sparse, weak; subparallel in posterior



FIGURES 7– 32. **7**, Ventral view of mesotrochanter and mesofemur of *Nirridessus pulpa*; **8**, ditto *N. windarraensis*; **9**, ditto *N. lapostaae*; **10**, ditto *Tjirtudessus eberhardi*; **11–12**, ventral views of mesotrochanter and mesofemur and metatrochanter and metafemur of *N. bigbellensis*; **13–14**, ditto *N. hinkleri*; **15–16**, ditto *N. cueensis*; **17–18**, ditto *N. morgani*; **19–20** ditto *T. magnificus*; **21–22**, ditto *T. hahni*; **23**, labial palpus of *T. eberhardi*; **24**, ditto *T. hahni*; **25**, ditto *T. magnificus*; **26**, ditto *N. bigbellensis*; **27**, ditto *N. hinkleri*; **28**, ditto *N. morgani*; **29**, ditto *N. cueensis*; **30**, ditto *N. windarraensis*; **31**, ditto *N. lapostaae*; **32**, ditto *N. pulpa*.

half; sides with dark suture in middle near anterior edge. Antenna stout, basal two segments largest, next six segments narrower at base, subequal, segment six the widest, apical segment twice as long as penultimate (Fig. 2); each segment with some very small setae on inside apically. Maxillary palpus relatively thin, elongate; apical segment largest, some sensillae towards tip, tip weakly bifid. Labial palpus not particularly thin; apical two segments subequal; tip weakly bifid; penultimate segment with two setae near apex arising from slight bulge (Fig. 24).

Pronotum: Broad, a little narrower than elytra (Fig. 2); anterolateral angles projecting strongly forward; base quite strongly narrowed; posterolateral angles acute; smooth, punctures sparse, very small, a row of stronger punctures along front margin; basal plicae short, very weak, only visible in some lights; row of long setae laterally, denser towards front.

Elytra: Not fused; lacking inner ridges; elongate, widest behind middle. Elytron smooth, quite densely and evenly covered with small punctures each with a small seta, row of widely spaced larger punctures close to inner edge; some setiferous micropunctures at base, near suture and near apex; row of long setae near lateral edge, a few additional long setae, more frequent towards sides. Epipleuron broad in anterior fifth, then rapidly narrowing to be virtually absent over rest of elytron.

Ventral surface: Prothoracic process relatively broad, strongly narrowed between coxae, not reaching mesothorax, apical half spatulate, tip rounded, strongly arched in lateral view with highest point (viewed ventrally) between coxae. Mesocoxae meet. Metathorax sharply triangular in front in midline, wings very narrow, broadly rounded in midline behind. Metacoxal plates large; metacoxal lines short, weak, widely spaced, almost obsolete; punctures very sparse, very weak; closely adpressed to first abdominal ventrite. First and second ventrites fused, sutural line virtually obliterated, ventrites three to five mobile, moderately covered with small seta-bearing punctures, ventrites three and four with a long central seta or bunch of long setae.

Legs: Protibia moderately broad, inner edge straight, outer edge bowed, widest past middle where it is about three times its basal width; protarsi weakly expanded, second segment about half length of first, third segment equal in length to first, fourth segment very small and hidden within deeply lobed third segment, apical segment long, thin, segments one to three with dense covering of adhesive setae, claws relatively strong, simple. Mesotrochanter parallel-sided broadly triangular at apex with a few setae on inner edge, mesofemur with a row of five to six relatively weak setae along hind edge in basal half (Fig. 21); mesotarsi more elongate than protarsi. Metatrochanter curved on outer edge straight on inner edge (Fig. 22), metafemur elongate, sinuate (Fig. 22), metatibia weakly curved, widening towards apex; metatarsi elongate, basal segment longest, apical segment a little longer than fourth, segments one and two in combination about as long as others; claws weak.

Male: Antennae and tarsi as in female. Median lobe of aedeagus narrow, twisted slightly, knobbed at apex; paramere broad, two-segmented, apical segment with pronounced, narrow, apical lobe (Fig. 37).

Etymology

This species is named after Hans Jurgen Hahn who assisted with describing the physicochemical environment occupied by the stygofauna. The type locality is an excellent example of this kind of habitat.

Remarks

T. hahni resembles *T. magnificus* in its large size and broad body but differs in its much less expanded pro- and mesotarsi and in its more normal antennae which have segments 5–10 subequal in size. It can be separated from both *T. magnificus* and *T. eberhardi* by the median lobe of the aedeagus which is noticeably twisted and has a rounded knob at the tip and by its pronotum which, unlike in those species, is a little narrower than the elytra.

Nirridessus Watts & Humphreys, 1999.

Nirridessus hinkleri sp. nov.

Types

Holotype: m, 'BES 7134, SB 32/1, 26°52'31"S, 120°12'05"E, 17/5/99, coll. W. F. Humphreys & H. J. Hahn', slide mounted, WAM, registration number 26843.

Paratypes: 58, same data as holotype, 29 WAM, registration number 26844, 28 SAMA; 3, 'BES 7130, TPB25/4, 26°52'50"S, 120°09'44"E, 17/5/99', 1 WAM, registration number 26845, 2 SAMA; 3, 'BES 7218, 26°51'37"S, 120°18'05"E, 22/5/99', 2 WAM, registration numbers 26846, 26847, 1 SAMA; 34, 'BES 7137, SB32/1,

26°52'31"S 120°18'05"E', 12 WAM, registration number 26848, 15 SAMA; 3, 'BES 7136, 26°52'31"S 120°12'05"E', WAM, registration numbers 26849, 26850, 26851; 1, 'BES 7166, 26°41'14"S 120°18'09"E', WAM, registration number 26852; 2, BES 7228, 1 WAM, registration number 26853, 1 SAMA. All collected by W. F. Humphreys & H. J. Hahn.

Additional specimen

The following partial specimen probably belongs to this species. BES 7222 Hinkler calcrete east, 26°51'36"S, 120°18'05"E, 22/5/99, coll. W. F. Humphreys & H. J. Hahn. WAM registration number 26854.

Description (number examined, 106) Figs 3, 13, 14, 27, 35.

Habitus: Length 1.4–1.8 mm.; relatively flat, elongate, pronotum narrowing at base; uniformly very light testaceous; hindwing vestigial, reduced to about one half length of elytron.

Head: Broad, parallel sided in basal half, rapidly narrowing forward of area where eye would be; a short dark suture at each side in middle at edge; reticulation moderate; punctures sparse, weak, row of setiferous punctures running backwards from above antennal base. Antenna moderately stout (Fig. 3), basal segment parallel sided, second segment rounded, third much narrower than second, fourth much shorter, then approximately the same size until penultimate, apical segment thinner and about twice as long as penultimate, a few small setae near apex of each segment. Tip of last segment of maxillary palpus very weakly bifid, a few small setae towards tip, penultimate segment much shorter than apical, with small papilla bearing two setae near apex (Fig. 27).

Pronotum: A little narrower than elytra (Fig. 3), broad in front, narrowing behind, strongly extended forward at anterolateral angles, posterolateral angles acute; punctures very sparse, weak, a few larger punctures towards front edge; moderately reticulate; basal plicae weak, straight, reaching about half way along pronotum; row of long, thin setae in front half at edges and on forward extensions.

Elytra: Not fused but tightly locked; lacking inner ridges; widest in middle; punctures very fine, very sparse, each with a small seta, a few punctures with longer setae; moderately reticulate; moderately covered with micropunctures at base, near suture and apex; sides of elytra quite strongly vertical, with row of long thin setae at edge, denser towards front. Epipleuron present in anterior quarter, absent in apical half.

Ventral surface: Pronotal process arched in lateral view, highest point (viewed ventrally) between coxae, apical half roughly parallel-sided, bluntly pointed, narrowing between coxae, not reaching metathorax. Mesocoxae in contact in midline. Metathorax with a few very small punctures; quite sharply triangular in midline in front; wings very narrow, subobsolete; narrowing to a broad point behind in midline. Metacoxal lines, well separated, weakly diverging, reaching to about halfway to mesosternum; sparsely punctate; adpressed to first abdominal ventrite. Metacoxal plates and first and second ventrites fused but sutures evident, other ventrites free, sternites three and four with central group of setae, otherwise virtually without setae; virtually impunctate.

Legs: Protibia relatively thin, about four times as broad at apex than at base; protarsi weakly expanded, second segment about a quarter the length of first, fourth segment very small, hidden within deeply bilobed third segment, adhesive setae sparse, weak; claws weak. Mesotrochanter relatively large, rounded with a few setae on inner edge; mesofemur with three to four strong spines on hind edge restricted to basal half but not all grouped near base (Fig. 13); mesotarsi less strongly expanded than protarsi. Metatrochanter large, outer edge curved, inner edge straight, weakly pointed, well separated from femur at apex (Fig. 14); metafemur relatively narrow, anterior edge weakly sinuate, impunctate, without spines; metatibia strongly curved, thickening apically; metatarsal segments elongate, progressively smaller towards apical segment which is a little longer than penultimate, combined length of basal two segments approximately equal to other three; claws weak, outer one slightly smaller than inner.

Male: Appendages and legs as for female. Median lobe of aedeagus moderately broad, concave above, tip broadly rounded with small central point; parameres moderately broad, two segmented, apical segment with pronounced narrow apical portion (Fig. 35).

Etymology

The name pertains to the Hinkler Well Catchment in which the classic study of the hydrogeochemistry of ground water calcretes was undertaken (Mann and Deutscher 1978).

Remarks

This is a small species with a distinctive

aedeagus. The pointed rather than rounded metatrochanters and acute rather than rectangular posterolateral angles to the pronotum, will separate it from the similar sized *N. lapostaae*.

Nirridessus cueensis sp. nov.

Types

Holotype: m. 'BES 7040, Old Cue water supply bores, 27°16'11"S, 117°59'23"E, 12/5/99, coll W. F. Humphreys & H. J. Hahn', slide mounted, WAM, registration number 26856.

Paratypes: 6, same data as holotype, 2 SAMA, 4 WAM, registration numbers 26857, 26858, 26859, 26860; 8, same data as holotype except for, 'BES 7067, 13/5/99', 4, SAMA 4, WAM, registration numbers 26861, 26862, 26863, 26864; 2, same data as holotype except for 'BES 7038', WAM, registration numbers 26865, 26866.

Description (number examined, 18) Figs 4, 15, 16, 29, 34.

Habitus: Length 2.1–2.4 mm.; relatively flat, elongate, pronotum a little narrower than elytra, constricted at base; uniformly very light testaceous; hindwing vestigial, reduced to about one half length of elytron.

Head: Broad, parallel sided in basal half, rapidly narrowing forward of area where eye would be; a short dark suture at each side in middle at edge; reticulation very weak; punctures sparse, weak, row of setiferous punctures running backwards from above antenna base. Antenna stout, robust, basal segment cylindrical, second more elongate, third smaller narrowing to base, then progressively widening until penultimate, apical segment thinner and slightly longer, a few small setae near apex of each segment. Last segment of maxillary palpus relatively broad, tip weakly bifid, a few small setae towards tip. Penultimate segment of labial palpus with strong cone-like projection near apex bearing two setae, approximately two thirds length of apical (Fig. 29).

Pronotum: Same width or a bit narrower than elytra, broad in front, narrowing quite markedly behind, strongly extended forward at anterolateral angles, posterolateral angles rectangular; punctures sparse, weak; weakly reticulate; two fine, basal plicae weakly impressed, straight, reaching about a half way along pronotum; row of long, thin setae in front half at edges and on forward extensions.

Elytra: Not fused but tightly locked, lacking inner ridges; widest in middle; punctures very fine, sparse, each with a small seta, a few punctures with longer setae; a few micropunctures near apex; sides of elytra quite strongly vertical; with row of long thin setae at edge, denser towards front. Epipleuron broad in front, narrowing quite rapidly to level of first sternite, then thin to apex, difficult to differentiate from disc.

Ventral surface: Pronotal process arched in lateral view, highest point (viewed ventrally) between coxae, apical half broadly spatulate, narrowing between coxae, not reaching metathorax. Mesocoxae in contact in midline. Metathorax with a few very small punctures; quite sharply triangular in midline in front; wings very narrow, subobsolete; rounded behind. Metacoxal plates with weakly raised central portion; metacoxal lines weak, well separated, diverging in anterior third, reaching to about halfway to mesosternum; sparsely punctate; adpressed to first abdominal ventrite. Metacoxal plates and first and second ventrites fused but sutures evident, other ventrites free, ventrites three and four with central group of setae, otherwise virtually without setae; virtually impunctate.

Legs: Protibia about three times as broad at apex than at base; protarsi moderately expanded, second segment half length of first, third segment deeply bilobed, a little longer than first, fourth segment very small and hidden within bilobed third segment, adhesive setae moderately dense; claws moderate. Mesotrochanter rounded at tip with some setae on inner edge (Fig. 15); mesofemur with three to five strong spines on hind edge grouped together near base (Fig.15); mesotarsi similar to protarsi. Metatrochanter large, outer edge rounded, inner edge straight, weakly separated from femur at apex (Fig.16); metafemur relatively narrow, anterior edge weakly sinuate, impunctate, without spines; metatibia strongly curved, thickening apically; metatarsal segments elongate, progressively smaller towards apical segment which is a little longer than penultimate, combined length of basal two segments approximately equal to other three; claws weak, outer one slightly smaller than other.

Male: Appendages and legs as above. Median lobe of aedeagus moderately broad, concave above, narrowing rapidly close to tip, small brush of setae dorsally near tip; parameres moderately broad, apical segment with pronounced narrow apical portion which partly overlaps basal portion (Fig. 34).

Etymology

This species is named after the type locality.

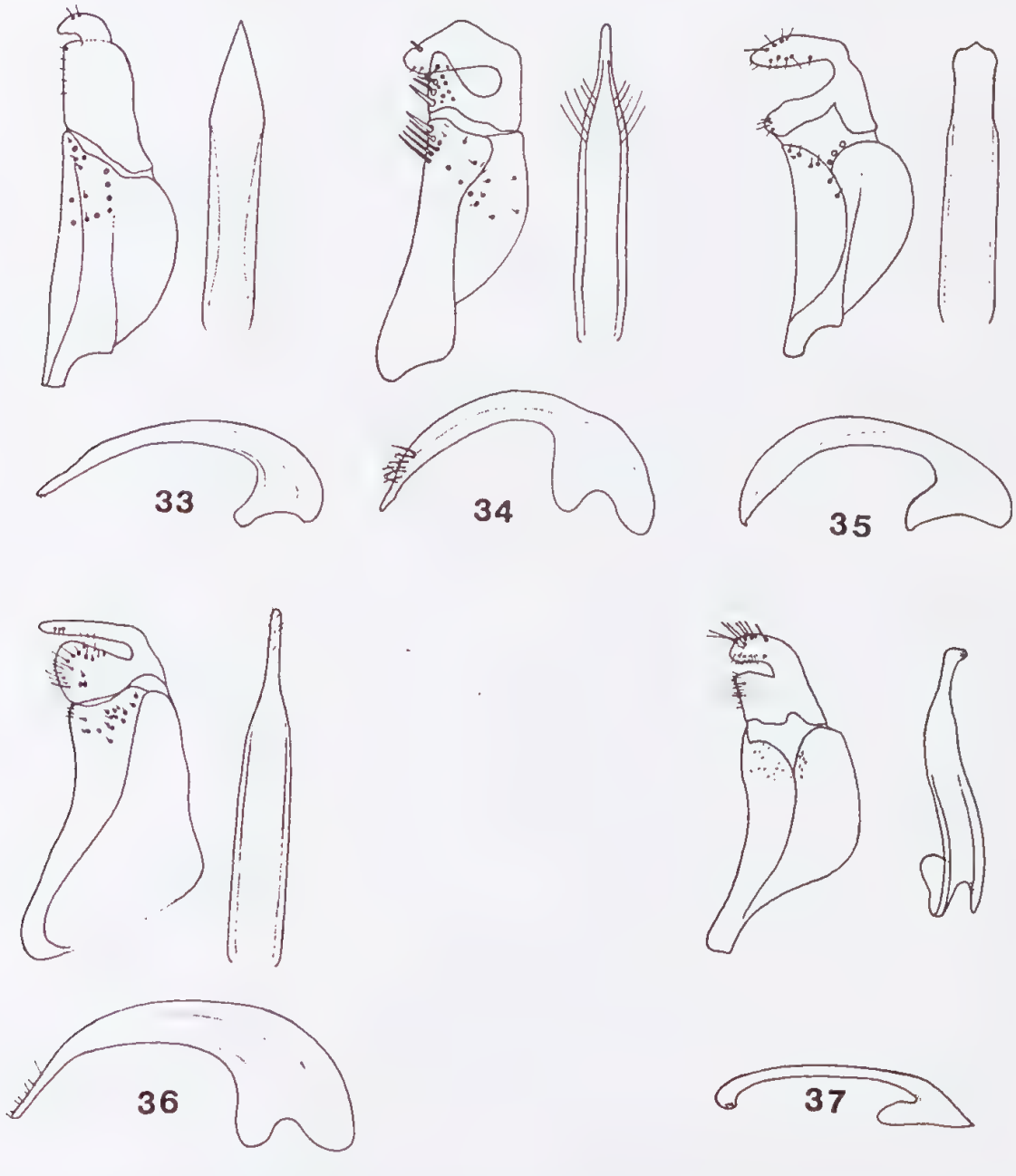
Remarks

Nirridessus cueensis seems close to *N. lapostaae* but is larger, its pro- and mesotarsi are much broader and its metatrochanters are not as rounded. The spines/strong setae on the hind edge of the mesofemur are grouped together near the base whereas in *N. lapostaae* they are more spread out along the basal half of the femur. The aedeagus differs from most *Nirridessus* by having a group of setae near the apex. The parameres are unique in *Nirridessus* in having the apical lobe overlapping part of the rest of the paramere and with strong spines on the inner edge (Fig. 34).

Nirridessus morgani sp. nov.

Types

Holotype: m. 'BES 7192, Sample 2 Site 284,



FIGURES 33–37. **33,** Paramere, dorsal view of central lobe and lateral view of central lobe of aedeagus of *Nirridessus morgani*; **34**, ditto *N. cueensis*; **35**, ditto *N. hinkleri*; **36,** ditto, *Tjirtudessus magnificus*; **37,** ditto *T. hahni*.

mineral exploration bore, 26°41'15"S, 120°21'10"E; 21/5/99, coll W. F. Humphreys & H. J. Hahn', in spirit, WAM, registration number 26867.

Paratypes: 6, as for holotype, 4 SAMA, 2 WAM, registration numbers 26868, 26869; 5, 'BES 7171, Site 262, mineral exploration bore, Lake Way, 26°68'74"S 120°35'31"E, 19/5/99', 1 SAMA, 4 WAM, registration numbers 26870, 26871, 26872, 26873.

Description (number examined, 10) Figs 6, 17, 18, 28, 33.

Habitus: Length 2.1–2.2 mm; relatively flat but deep bodied, elongate, pronotum weakly narrowing at base; uniformly very light testaceous; hindwing vestigial, reduced to about one half length of elytron.

Head: Relatively narrow, parallel sided in basal half, rapidly narrowing forward of area where eye would be; a short dark suture at each side in middle at edge; very weak reticulation; punctures sparse, weak, row of setiferous punctures running backwards from above antenna base; weakly reticulate. Antenna relatively stout, basal two segments broad, third narrower, fourth similar to third, then approximately equal in size until penultimate, apical segment a bit longer but same width, a few small setae near apex of each segment. Tip of last segment of maxillary palpus weakly bifid, a few small setae towards tip. Penultimate segment of labial palpus shorter than apical, with two setae on slight bulge near apex (Fig. 28).

Pronotum: Much narrower than elytra, narrower behind, strongly extended forward at anterolateral angles, posterolateral angles square; punctures very sparse weak, a few larger punctures towards front edge; two strongly raised basal plicae, straight, reaching about half way along pronotum; row of long, thin setae in front half at edges and on forward extensions.

Elytra: Fused but may open slightly in preparations, lacking inner ridges; sides subparallel in middle; punctures very fine, sparse, each with a small seta, a few punctures with longer setae; moderately covered with micropunctures particularly at base, near suture and apex; sides of elytra quite strongly vertical; with row of long thin setae at edge, denser towards front. Epipleuron broad in front quarter, narrowing quite rapidly to middle, absent in apical half.

Ventral surface: Pronotal process arched in lateral view, highest point (viewed ventrally) between coxae, apical half parallel sided, tip weakly and bluntly pointed, narrowing between coxae, not reaching metathorax. Mesocoxae in contact in midline. Metathorax with a few small punctures; broadly triangular in midline in front; wings very narrow; narrowing to blunt point behind. Metacoxal plate with weakly raised central portion; metacoxal lines well separated, progressively diverging, reaching to about halfway to mesosternum; sparsely punctate; adpressed to first abdominal ventrite. Metacoxal plates and first and second ventrites fused but sutures evident, other ventrites free, ventrites three and four with central group of setae, otherwise virtually without setae; virtually impunctate.

Legs: Protibia about three times as broad at apex than at base; protarsi weakly expanded, second segment not much shorter than first, the fourth segment very small and hidden within deeply bilobed third segment, adhesive setae sparse; claws weak. Mesotrochanter sharply pointed, without setae on inner edge; mesofemur with two strong setae on hind margin at base (Fig. 17); mesotarsi slightly less strongly expanded than protarsi. Metatrochanter large, completely exposed, pointed, close to metafemur at apex (Fig. 18); metafemur relatively narrow, anterior edge weakly sinuate, impunctate, without spines; metatibia curved, thickening apically; metatarsal segments elongate, progressively smaller towards apical segment which is a little longer than penultimate, combined length of basal two segments approximately equal to other three; claws weak, outer one slightly smaller than other.

Male: Appendages and legs as for female. Median lobe of aedeagus moderately broad, concave above, narrowing to tip, without setae; parameres moderately broad, apical segment relatively long with small apical lobe (Fig. 33).

Etymology

This species is named after Kevin Morgan for his understanding of the hydrology and geochemistry of the palaeodrainage channels in Western Australia (Morgan 1993).

Remarks

The well marked pronotal plicae and pointed metatrochanters suggest a relationship with *N. pulpa*. The lack of an eye remnant and thinner antennae will separate it from this species. The distinctive, small, apical lobe on the paramere and the group of strong spines on the hind edge of the mesofemur reduced to two will separate it from all other *Nirridessus*.

Nirridessus bigbellensis sp. nov.

Types

Holotype: f. 'BES 7050, borefield monitoring bore PAT 7, Austin Downs Pastoral Station, 27°24'48"S 117°42'40"E, 12/5/99', coll. W. H. Humphreys & H. J. Hahn', slide mounted, WAM, registration number 26874.

Paratype: f. (partial specimen) as for holotype, slide mounted, SAMA.

Description (number examined, 2) Figs 5, 11, 12, 26.

Habitus: Length 3.0–3.2 mm.; relatively flat and broad, pronotum weakly narrowing at base; uniformly very light testaceous; hindwing vestigial, reduced to about two-thirds length of elytron.

Head: Broad, parallel sided in basal half, rapidly narrowing forward of area where eye would be; a small oval area delineated by dark sutures at each side in middle at edge; very weak reticulation; punctures sparse, weak, row of setiferous punctures running backwards from above antennal base. Antenna relatively thin, basal two segments broadest, third as long as second but narrower, fourth shorter, then approximately equal in size until apical segment which is longer and thinner than penultimate, a few small setae near apex of each segment. Maxillary palpus relatively thin, apical segment as long as other three combined, tip of last segment truncated, a few small setae towards tip. Apical segment of labial palpus twice length of penultimate which has two setae on slight bulge near apex (Fig. 26).

Pronotum: Broad, narrower than elytra, strongly constricted near base, strongly extended forward at anterolateral angles, posterolateral angles acute; punctures very sparse, weak, a few larger punctures towards front edge; basal plicae subobsolete; row of long, thin setae in front half at edges and on forward extensions.

Elytra. Not fused, lacking inner ridges; sides rounded; punctures small, very sparse, setiferous, a few punctures with longer setae; some micropunctures near apex; row of long thin setae laterally, denser towards front. Epipleuron broad in front fifth, narrowing quite rapidly to middle, absent in apical half.

Ventral surface: Pronotal process arched in lateral view, highest point (viewed ventrally) between coxae, apical half parallel sided, tip weakly and bluntly pointed, narrowing between coxae, not reaching metathorax. Mesocoxae in contact in midline. Metathorax with a few small punctures; broadly triangular in midline in front; wings narrow; rounded behind in midline. Metacoxal plates sparsely punctate; metacoxal lines, relatively close, weakly diverging, reaching to about two thirds of way to mesosternum; adpressed to first abdominal ventrite. Metacoxal plates and first and second ventrites fused, other ventrites free, ventrites three and four with central group of setae, otherwise virtually without setae; virtually impunctate.

Legs: Protibia elongate about three times as broad at apex than at base; protarsi weakly expanded, second segment not much shorter than first, the fourth segment very small and hidden within deeply bilobed third segment, adhesive setae moderate; claws moderately strong. Mesotrochanter parallel sided, apex rounded with a few setae on inner edge; mesofemur with six strong setae on hind margin at base (Fig. 11); mesotarsi more elongate than protarsi. Metatrochanter large, inner edge curved, outer edge straight, rounded at tip, well separated from femur at apex (Fig. 12); metafemur narrow, anterior edge weakly sinuate, impunctate, without spines; metatibia strongly curved, thickening apically; metatarsal segments elongate, progressively shorter towards apical segment which is a little longer than penultimate, combined length of basal two segments approximately equal to other three; claws weak.

Male: Not known.

Etymology

The name pertains to Big Bell Mine which draws its water from the aquifer in which the species lives.

Remarks

At over three millimetres in length the largest *Nirridessus* so far known. It also is more rounded in outline and less flattened than most. The thin maxillary and labial palpi, narrow metafemur and strongly acute posterolateral angles of the pronotum also set it apart.

Additional Specimens

Taxon 1

One small (length 1.5 mm) female specimen was collected at Lake Violet. Although close to *N. hinkleri* it probably represents a distinct species. More specimens, including males are needed to confirm this.

'BES 7160, observation bore for Pump 5,

Wiluna Gold Lake Violet Borefield, 26°41'08"S, 120°13'05"E 8/5/99, coll. W. F. Humphreys & H. J. Hahn', slide mounted, WAM, registration number 26875.

Taxon 2

Eight partial specimens of a large species (approximately 4.0mm long.), together consisting of pronotum, abdomen, elytra and male genitalia, but lacking head and all appendages, were collected at Lake Way. These represent a distinctive species of uncertain generic placement.

'BES 7222, Sample 3 Site 289 Hinkler calcrete east, unequipped water bore, 26°51'36"S, 120°18'05"E, 22/5/99, coll. W. F. Humphreys & H. J. Hahn', 4 in spirit, WAM, registration numbers 26876, 26877, 26878, 26879. 4 slide mounted, SAMA.

Larvae

Larvae of two very different taxa were collected at Austin Downs (type 1) and Lake Violet (type 2). Although bidessine they differ considerably from the two larval taxa described in our earlier paper (Watts and Humphreys 1999). In comparison to epigean bidessine larvae we would consider the four larval taxa to be generically distinct. None appear to belong to the very small *Kintingka kurutjutu* Watts and Humphreys. This conclusion is in conflict with the adult taxonomy. Association of larvae and adults and more collecting will be needed to resolve this.

Type 1: 1, 'BES 7021, borefield monitoring bore PAT 2, Austin Downs Pastoral Station , 27°23'44"S, 117°42'25"E, 11/5/99', slide mounted, WAM, registration number 26880; 1, 'BES 7050, borefield monitoring bore PAT 7, Austin Downs Pastoral Station , 27°24'48"S, 117°2'40"E, 12/5/99', in spirit, SAMA; 1, 'BES 7055 borefield monitoring bore PAT 1, Austin Downs Pastoral Station , 27°23'19"S, 117°43'33"E, 12/5/99', slide mounted, SAMA.

Type 2: 10, 'BES 7148, observation bore for

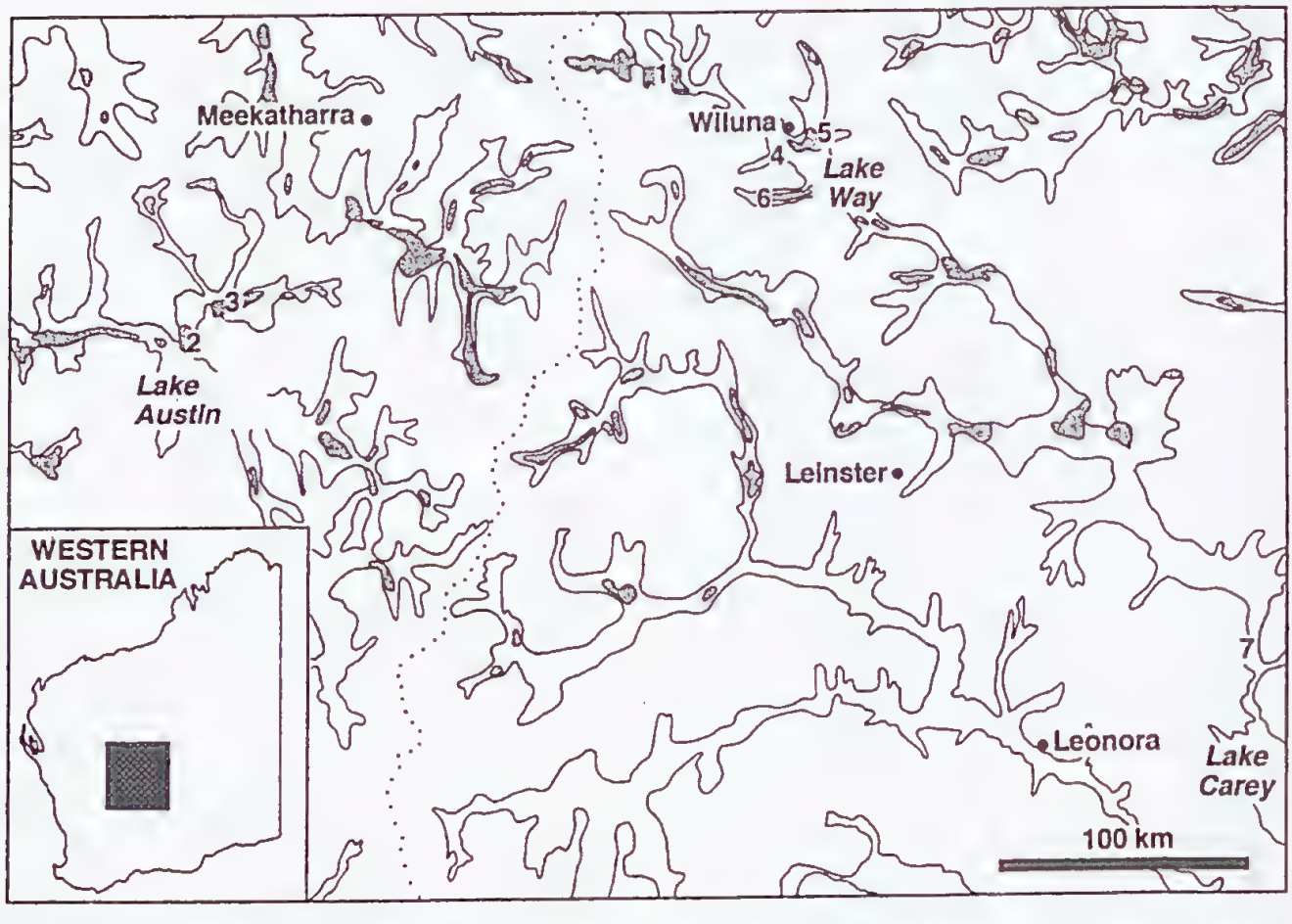


FIGURE 38. The distribution of stygal Dytiscidae in the Yilgarn Region. Groundwater calcrete deposits (shaded) are shown in the palaeodrainage channels (solid lines). The dotted line denotes the surface drainage divide (Beard 198); inland drainage to the east, Indian Ocean drainage to the west. The numerals denote discrete areas of calcrete (Table 1): 1, Paroo; 2, Austin Downs; 3, Cue; 4, Lake Violet; 5, North-east Lake Way; 6, Hinkler Well; 7, Mount Windarra.

TABLE 1. The distribution of stygal species of dytiscids amongst discrete calcrete bodies in the Yilgarn district of Western Australia.

Genus Calcrete body	*Tjirtudessus* W & H	*Nirridessus* W & H	*Kintingka* W & H
Western drainage			
Austin Downs	–	*bigbellensis* sp. nov.	–
Cue	[4]*magnificus* sp. nov.	[4]*cueensis* sp. nov.	–
Eastern drainage			
Paroo	[2]*eberhardi* W & H[1]	[2]*pulpa* W & H	[2]*kurutjutu* W & H
Lake Violet	–	undescribed sp.	–
NE Lake Way	*hahni* sp. nov.	*morgani* sp. nov.	–
Hinkler Well	–	*hinkleri* sp. nov.	–
Mount Windarra	[3]*lapostaae* W & H	[3]*windarraensis* W & H	–

[1] W & H = Watts & Humphreys 1999; [2] sympatric; [3] sympatric; [4]sympatric.

Pump 1, Wiluna Gold Lake Violet Borefield , 26°40'30"S, 120°13'55"E, 18/5/99'. 4 WAM, registration numbers 26881, 26882, 16883, 16884, 6 SAMA, slide mounted and in spirit; 1, same data but 'BES 7231, WAM, registration number 26885; 1, same data but 'BES 7242', WAM, registration number 26886. All collected by W. F. Humphreys and H. J. Hahn.

Discussion

Distribution

Dytiscid specimens were collected from six separate calcrete deposits: 1, Austin Downs (borefield for Big Bell Gold Mine); 2, Cue (former borefield for the town of Cue); 3, Paroo (pastoral station, detailed in Watts and Humphreys 1999); 4, Lake Violet at the northern end of Lake Way contains the borefield for Wiluna Gold Mine; 5, the Hinkler Well calcrete, the hydrogeochemistry of which is detailed in Mann and Deutscher (1978); and 6, the northeastern side of Lake Way adjacent to the Lakeway Uranium prospect (DCE 1981) (Fig. 38). Sites 1 and 2 drain towards the Indian Ocean whilst the remainder are to the east of the drainage divide in the Carey palaeodrainage system (sensu Morgan 1993) which drains to the interior of the continent. The distribution of the taxa by calcrete body is shown in Table 1.

No dytiscids or other large stygofauna were taken from open, hand dug, pastoral wells even if they were adjacent to narrow bores containing stygal dytiscids and other stygofauna. Despite sampling widely in non-calcrete aquifers no dytiscids were collected in other than calcrete aquifers, which confirms the conclusion of our earlier, much more restricted sampling, that the beetle and other larger stygofauna is restricted to aquifers in areas of calcrete (W. F. Humphreys unpublished; Watts and Humphreys 1999). In addition, this study extends the range of waters inhabited by stygal dytiscids, and other stygofauna, to saline water with a salinity of at least 20 g l^{-1}.

These discoveries significantly extend the known range of both *Tjirtudessus* and *Nirridessus* from the inland draining Lake Way/Lake Carey palaeodrainage channel to the seemingly never-connected Murchison palaeodrainage system that drains westward to the Indian Ocean. No Dytiscidae were discovered in stygofauna-rich calcrete aquifers in the Pilbara region. Since only about 9% of the major calcrete deposits in the palaeodrainage channels of Western Australia alone (Humphreys 1999) have been sampled for stygofauna it is likely that additional subterranean Dytiscidae remain to be discovered in Australia.

Associated fauna

The dytiscids were collected amongst a diverse stygofauna comprising mainly phreodrillid Oligochaeta, bathynellids (Syncarida), Ostracoda, cyclopoid and harpacticoid Copepoda, crangonyctoid and ceinid Amphipoda and *Haloniscus* (Oniscoidea: Isopoda).

Water quality

Fresh to saline groundwaters occur widely in calcretes and may be reached as close as two metres from the surface to more than 100 m below the surface. The calcrete aquifer itself may vary up to 30 m in thickness (Barnett and Commander

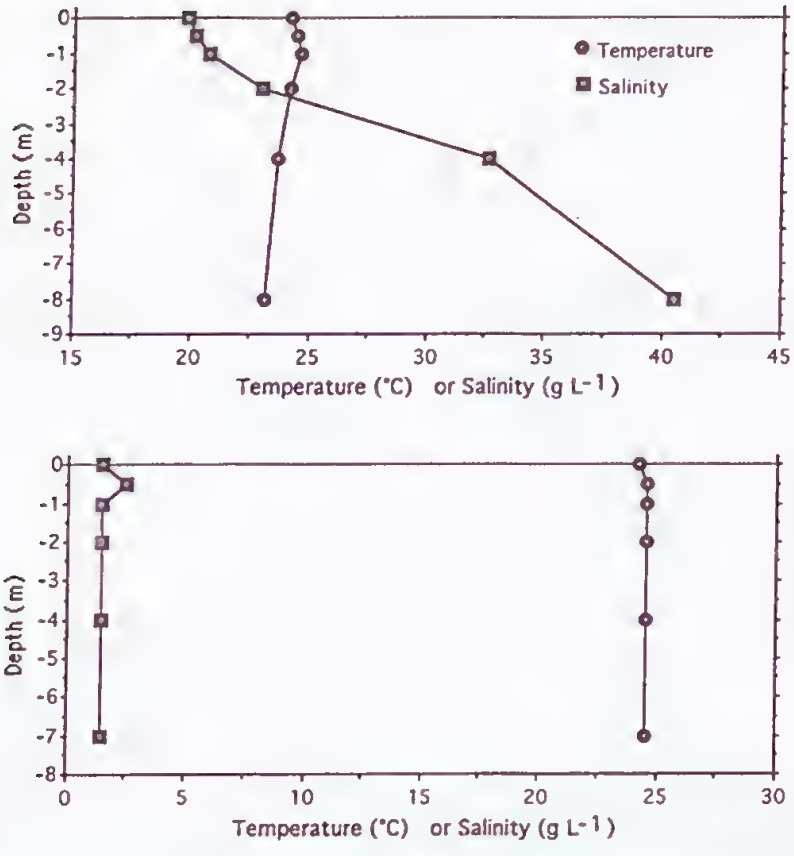


FIGURE 39. Physiochemical profiles in some aquifers from which dytiscid beetles were collected. Upper, site 286 NE Lake Way; lower, site 289 Hinkler East.

1985), but those sampled in the Yilgarn are typically thin and the groundwater is close to the surface (Table 2). The area is arid and rainfall (c. 200 mm per year) is irregular predominately as episodic heavy falls (Sanders 1973) which recharge the calcrete aquifers through the porous, often karstic (Barnett and Commander 1985), surfaces. Indeed, groundwater calcretes are carbonate deposits forming near the water table in arid lands as a result of concentration processes by near-surface evaporation and they are associated with slow moving groundwater that fluctuates widely in depth (Jacobson and Arakel 1986; Morgan 1993). In consequence the groundwater table varies quite widely between storm events and markedly in salinity. The dytiscids were collected from water of variable quality (Table 2) with samples collected from fresh water (salinity < 1000 mg l^{-1}) as well as saline conditions (salinity > 20 000 mg l^{-1}). At some locations the water was well stratified with marked changes in the physico-chemical conditions with depth, while at others the vertical profile was less marked (Fig. 39; Table 2).

Considerable seasonal variation occurs in the salinity of at least some of the habitats (foot note to table 2) but the effect of this on the distribution of the stygofauna is unknown. Marked seasonal changes in numbers have been reported for stygal dytiscids inhabiting alluvial aquifers near rivers (Ordish 1976), and it is known that changes to the water table and the direction of groundwater flow have profound effects on the location of such populations (Richoux and Reygrobellet 1986).

Palaeogeography and hydrology

While much is still to be learnt of these stygal dytiscids, it is worthwhile at this stage to consider the palaeogeographic and hydrological setting in which this fauna, and that reported by Watts and Humphreys (1999), occurs.

The Western Shield of Western Australia is divided from north to south by a drainage divide that separates the rivers, some still active, draining to the Indian Ocean, from those draining to the east and which are now largely inactive and disorganised (Beard 1998). The present drainage, now mostly a palaeodrainage system, formed during the Mesozoic when the Western Shield was attached to Antarctica (Beard 1998; van de Graaf *et al.* 1977; Morgan 1993). The sediments infilling the palaeochannels are mostly Eocene or later but the age of the calcretes is unknown. Morgan

TABLE 2. Physico-chemical characteristics of sites from which stygal dytiscids were recorded.

Site	Sample depth (m)	Salinity g L^{-}	Temperature °C	Dissolved O_2 % sat	mg L^{-1}	pH	[2]Depth to water (m)	[2]Depth of water(m)
PAT2 – Austin Downs	–	5[1]	–	–	–	–	4.8	6
PAT1 – Austin Downs	–	8[1]	–	–	–	–	8	4.8
Old Cue town bore	–	5	25	50.5	3.9	–	4	0.5
GSWA5 surface- Paroo	–	1.38	26.7	59.7	4.5	7.7	3.6	[3]4
GSWA5 deep- Paroo	–	–	–	49	3.7	–	–	–
GSWA6 surface- Paroo	–	0.77	24.8	59.7	4.6	7.5	5	[3]6.6
GSWA6 deep- Paroo	–	0.79	24.7	43.5	3.4	7.5	–	–
GSWA15 small- Paroo	–	0.53	26	59.2	4.5	8.4	3	[3]8
GSWA15 small- Paroo	–	0.6	25.3	38.6	3	7.9	–	–
SB 32/1 – Hinkler west	–	1.66	26.9	79.2	6	7.7	4.8	2
TPB 25/4 – Hinkler west	–	2	–	–	–	–	4.8	34
OB Pump 1 – Lake Violet	–	2.36	24.6	88.7	7	8.2	4.8	5.6
262 – NE Lake Way	–	4.46	25.7	86.1	6.6	7.6	4	1.6
286 – NE Lake Way	0	19.8	24.2	23	1.8	–	2	20
286	0.5	20.1	24.4	–	–	–	–	–
286	1	20.7	24.6	–	–	–	–	–
286	2	23	24.2	–	–	–	–	–
286	4	32.6	23.7	–	–	–	–	–
286	8	40.5	23.2	–	–	–	–	–
288 – Hinkler east	0	1.46	24.2	68.6	5.4	8.3	2.4	19
288	0.5	2.43	24.5	–	–	–	–	–
288	1	1.43	24.5	–	–	–	–	–
288	2	1.42	24.5	–	–	–	–	–
288	4	1.42	24.5	–	–	–	–	–
288	7	1.42	24.5	–	–	–	–	–
289 – Hinkler east	0	1.56	24.4	74.4	5.9	8	2.4	19
289	0.5	1.7	24.6	–	–	–	–	–
289	1	2.04	24.5	–	–	–	–	–
289	2	2.1	24.5	–	–	–	–	–
289	4	2.12	24.5	–	–	–	–	–
289	8	2.15	24.5	–	–	–	–	–

[1] PAT1 and PAT2 have annual salinity variation between 5–9 g l^{-1} and 5–22 g l^{-1} respectively as determined from borefield monitoring by Big Bell Mine. [2] Depth approximate. [3] To base of calcrete (Sanders 1972).

(1993) considered it likely that they formed from the start of the Oligocene following the onset of the continental aridity but they have probably been remobilized and redeposited. As this process is continuing it is not possible to date the calcretes using standard radiometric methods.

The Yilgarn Craton covers 750,000 km^2 of southwestern Australia between latitudes 34° and 25° S and has mostly not been submerged by the sea since the beginning of the Mesozoic. The northeastern half is semi-arid with unreliable rainfall that may fall throughout the year.

The central watershed traverses a palaeosurface barely modified since the Cretaceous (Beard 1998). This central watershed is of fairly uniform elevation traversed only by a few minor gaps or low points that may be indicative of a change to the drainage patterns in the distant past. One of these is on Killara Station where a col, 50–100 m below the level of the adjacent watershed, separates the Murchison and the Carey (Lake Way-Lake Carey in Watts and Humphreys 1999) palaeodrainage systems (Beard 1998) which together encompass the entire distribution of the Australian stygal dytiscids known to this time. While it is tempting to invoke some significance of this gap to the biogeography of the stygofauna, this minor gap may merely reflect the trend of less resistant Proterozoic rocks (Beard 1998).

The collection sites at Cue and Lake Austin

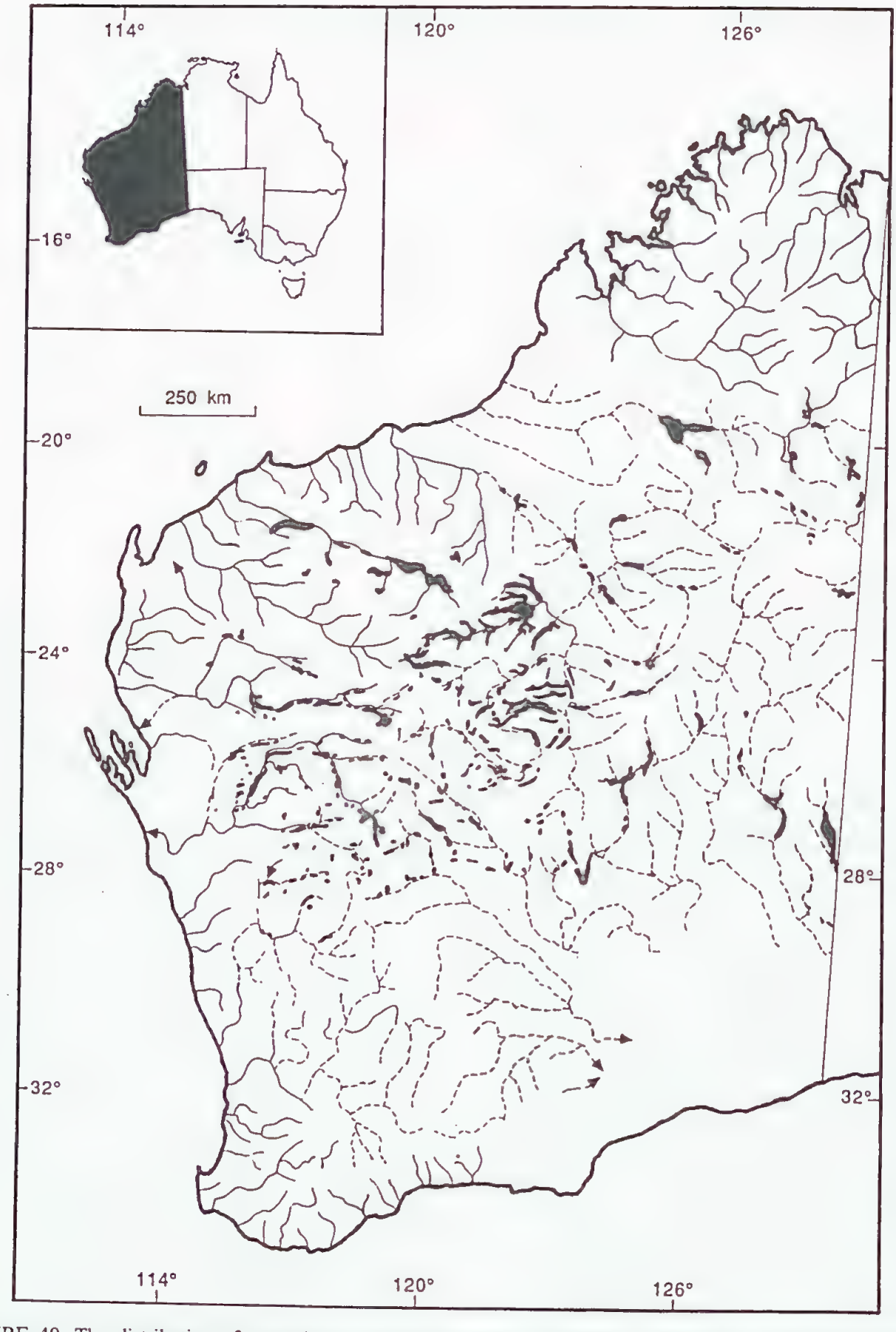


FIGURE 40. The distribution of groundwater calcrete aquifers in Western Australia (from Humphreys 1999). Modern and palaeo-drainage (respectively, continuous and dashed lines) and calcrete areas (black) are shown. Derived from data in Geological Survey (1989), drawn by Julianne Waldock on a base map provided by Philip Commander (further details in Humphreys 1999).

(containing *Tjirtudessus magnificus*, *Nirridessus cueensis* and *Nirridessus bigbellensis*) are separated from those to the east (containing *Tjirtudessus hahni*, *Nirridessus hinkleri* and *Nirridessus morgani* plus the five species in Watts and Humphreys 1999) by the continental water divide (Beard 1998) between the inland drainage and that draining to the Indian Ocean. As the water divide is also the approximate water divide for the palaeodrainage systems that date from at least the Cretaceous no subterranean hydrological connection is likely to have occurred. The presence of congeneric stygal species on either side of this water divide suggests that the fauna colonised groundwater from a widespread epigean ancestor, possibly driven by the increasing aridity of central Australia since the Eocene.

Groundwater calcretes stretch through arid central Australia as far as the border of the Northern Territory and Queensland (Fig. 40; Humphreys 1999). Similar calcretes occur on the Pilbara Craton which comprises much of the rest of the Western Shield of Australia, and there also, each discrete calcrete area sampled so far contains a distinct stygofauna (Poore and Humphreys; W. F. Humphreys and S. M. Eberhard, unpublished; S. M. Eberhard, unpublished; S. M. Eberhard and W. F. Humphreys unpublished). However, no dytiscids have been taken from the Pilbara Craton.

Each of the seven discrete, but sometimes adjacent, calcrete areas sampled from the palaeodrainage lines on the Yilgarn Craton (herein and Watts and Humphreys 1999) contains a distinct assemblage of dytiscids (and probably other stygofauna). The data represented here contains samples from only two of 42 major calcretes areas in the upper Murchison catchment, and five out of 18 major calcrete areas in the Carey palaeodrainage system. In Western Australia alone there are about 210 major calcrete areas divided amongst about five major drainage systems (Fig. 40)

Each calcrete sampled in the Yilgarn (and Pilbara) containing stygofauna has a unique stygofaunal community and as only a small proportion of the available calcrete areas have been sampled, this suggests that there is considerable biodiversity to be unearthed amongst the dytiscids and in the arid zone stygofauna generally.

Changes to the water table and the direction of groundwater flow may have profound effects on the location of populations of stygal dytiscids (Richoux and Reygrobellet 1986) and unique stygal assemblages, including Dytiscidae, may be lost if groundwater pollution occurs (Uéno 1996). As the stygofaunas are unique with circumscribed distributions and they occur in systems of potential or actual resource developments, they present a real challenge for innovative environmental management. Furthermore, these calcrete aquifers are sufficiently replicated and contain a diversity of fauna sufficient to test independently theories and processes that gave rise to the vicariance within these systems.

While much work is needed to start to understand distribution patterns, the faunistic distinctiveness of the groundwater calcrete aquifers is consistent with the evolution of the hydrogeological system in the palaeodrainage channels as interpreted by Morgan (1993). In essence, Morgan argues that in the palaeorivers north of latitude 30°S separate geochemical systems develop associated with the formation of each salt lake (playa) along a palaeodrainage system. In the groundwater there is a well defined change in common ion ratios developed with increasing salinity marked especially by a relative increase in chloride and sulphate with respect to other ions—this may contribute to the heterogeneity in stygofauna distribution within a given calcrete area reported by Poore and Humphreys (1998). As it is related to the rate of movement of the groundwater, this increase in salinity and relative chloride/sulphate content is both spatial and temporal because the change takes place between widely separate intake and outflow locations. This hydrochemical trend commences at the headwaters of each recharge system, such as a large alluvial fan, and completes its cycle at the evaporation outlet marked by the lower boundary of the calcrete with a salt lake. The main channel calcretes are formed at the downstream end of an individual hydrochemical system and immediately upstream of an evaporation outflow area forming a salt lake (Morgan 1993). Several similar hydrochemical cycles may occur along a single palaeodrainage system.

The marked age and stability of the palaeodrainage systems themselves, coupled with the repeated cycles of fresh to hypersaline (>200 g l^{-1}) groundwaters along the length of each palaeodrainage system would effectively isolate each stygal assemblage within the region where groundwater characteristics are suitable for their development.

Acknowledgments

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References

BARNETT, J. C., & COMMANDER, D. P. 1985. Hydrogeology of the western Fortescue Valley, Pilbara Region, Western Australia. *Geological Survey Record* 1986/8. (Western Australia Geological Survey, Perth).

BEARD, J. S. 1998. Position and development history of the central watershed of the Western Shield, Western Australia. *Journal of the Royal Society of Western Australia* **81**: 157–164.

DCE. 1981. Proposed Lakeway Uranium Project. *Department of Conservation and Environment, Bulletin* **106**. 64 pp.

GEOLOGICAL SURVEY. 1989. Hydrogeological map of Western Australia, 1: 2,500,000. *Geological Survey of Western Australia*, Perth.

HUMPHREYS, W. F. 1999. Relict stygofaunas living in sea salt, karst and calcrete habitats in arid northwestern Australia contain many ancient lineages. Pp. 219–227. *in* W. Ponder and D. Lunney (eds). The Other 99%. The Conservation and Biodiversity of Invertebrates. *Transactions of the Royal Zoological Society of New South Wales*, Mosman 2088.

JACOBSON, G., & ARAKEL, A. V. 1986. Calcrete aquifers in the Australian arid zone. *Proceedings of the International Conference on Groundwater Systems Under Stress, Brisbane.* Australian Water Resources Council. Pp. 515–523.

MANN, A. W., & DEUTSCHER, R. L. 1978. Hydrogeochemistry of a calcrete-containing aquifer near Lake Way, Western Australia. *Journal of Hydrology* **38**: 357–377.

MORGAN, K. H. 1993. Development, sedimentation and economic potential of palaeoriver systems of the Yilgarn Craton of Western Australia. *Sedimentary Geology* **85**: 637–656.

ORDISH, R. G. 1976. Two new genera and species of subterranean water beetles from New Zealand (Coleoptera: Dytiscidae). *New Zealand Journal of Zoology* **3**: 1–10.

POORE, G. C. B., & HUMPHREYS, W. F. 1998. First record of Spelaeogriphacea from Australasia: a new genus and species from an aquifer in the arid Pilbara of Western Australia. *Crustaceana* **71**: 721–742.

RICHOUX, P., & REYGROBELLET, J. L. 1986. First report on the ecology of the phreatic water beetles (Coleoptera, Dytiscidae). *Entomologia Basiliensia* **11**: 371–384.

SANDERS, C. C. 1973. Hydrogeology of a calcrete deposit on Paroo Station, Wiluna, and surrounding areas. *Western Australian Geological Survey Annual Report 1972*, pp. 15–26.

SPANGLER, P. J. 1986 Insecta: Coleoptera. *In* 'Stygofauna. A Faunistic, Distributional, and Ecological Synthesis of the World Fauna inhabiting Subterranean Waters (Including the Marine Interstitial).' 622–631. Ed. L. Botosaneau. E. J. Brill: Leiden.

UÉNO, S-I. 1996. New Phreatobiontic Beetles (Coleoptera, Phreatodytidae and Dytiscidae) from Japan. *Journal of the Speleological Society of Japan* **21**: 56.

VAN DE GRAFF, W. J., CROWE, R. W. A., BUNTING, J. A., & JACKSON, M. J. 1977. Relict early cainozoic drainages in arid Western Australia. *Zeitschrift für Geomorphologie* **21**: 379–400.

WATTS, C. H. S., & HUMPHREYS, W. F. 1999. Three new genera and five new species of Dytiscidae (Coleoptera) from underground waters in Australia. *Records of the South Australian Museum* **32**: 121–142.

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